CERES Cloud Properties: Update Spring 2016

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G. Hong (models, night tau), M. Nordeen (GEO),
R. Palikonda (GEO), B. Scarino (cal, Tskin), B. Shan (GEO avg),
R. Smith (web, NPP), D. Spangenberg (everything), C. Yost (phase, validation)

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P. Heck (retrieval code)

CIMSS, Univ. Wisconsin, Madison, WI

X. Dong, B. Xi (validation)

University of North Dakota, Grand Forks, ND, USA

Thanks to Dave Doelling and his calibration team!

Topics

- Publications
- Status
- Validation
- Trends and Variations
- GEO clouds
- Changes for Edition 5

Update of CERES Cloud-related Papers since Oct 2015

Edition-2 related

Wang, S., A. H. Sobel, A. Fridlind, Z. Feng, J. Comstock, P. Minnis, and M. L. Nordeen, 2015: Simulations of cloud-radiation interaction using large-scale forcing derived from the CINDY/DYNAMO northern sounding array. *J. Adv. Model. Earth Syst.*, **7**, 1472-1498, doi:10.1002/2015MS000461.

Edition-4 related

Painemal, D., T. Greenwald, M. Cadeddu, and P. Minnis, 2016: First extended validation of satellite microwave liquid water path with ship-based observations of marine low clouds. *Geophys. Res. Lett.*, submitted.

Dong, X., B. Xi, S. Qiu, P. Minnis, S. Sun-Mack, and F. Rose, 2016: A radiation closure study of Arctic cloud microphysical properties using the collocated satellite-surface data and Fu-Liou radaitive transfer model. *J. Geophys. Res.,* submitted.

CERES, 2016: Edition 4 SSF Data Quality Summary.

Minnis et al., 2016: CERES Satellite ClOud and Radiation Property retrieval System (SatCORPS) Update; MODIS Edition 4 and VIIRS Edition 1 Algorithms. In preparation.

Chang, F.-L., P. Minnis, S. Sun-Mack, and Y. Chen, 2016: A CO2 overlapping cloud property retrieval scheme applied to CERES-MODIS data. In preparation.

Edition-5 related

Minnis, P., G. Hong, S. Sun-Mack, W. L. Smith, Jr., and S. Miller, 2016: Estimation of nocturnal ice cloud optical depth and water path from MODIS multispectral infrared radiances using a neural network method. *J. Geophys. Res., in press*

Y. B., P. Yang, P. Minnis, N. Loeb, and S. Kato, 2016: Ice cloud optical property parameterization based on a two-habit model for applications to global circulation models. *J. Climate, submitted*

Scarino, B. R., P. Minnis, T. Chee, K. M. Bedka, C. R. Yst, and R. Palikonda, 2016: Global clear-sky surface skin temperature from multiple satellites using a single-channel algorithm with viewing zenith angle correction. *Atmos. Meas. Tech. Discuss*.

CERES MODIS Status (Coll 5 Data)

- Ed2 processing
  - *Aqua: through Dec 2015, will continue until ED4 ADMs completed*
  - *Terra: through DEc 2015, will continue until Ed4 ADMs completed*

- Ed4 Beta-2 processing
  - *Aqua: through December 2015*
  - *Terra: through January 2015*

CERES VIIRS Status

- Ed1 delivered,4 years completed
  - *Jan 2012 – Dec 2015*

CERES GEOSat Status

- Ed4-beta: uses 3/4 channel cloud retrievals with appropriate satellites
  - *through July 2015*
  - *cleaning continues and algorithms being updated*

CERES Data Quality Summaries

- DQS clouds validation for Ed4 waiting for remainder of document
    - Full DQS not available yet, but copy of clouds validation available
- DQS Validation started for VIIRS Ed1
- DQS validation for GEOSat analyses next

North Slope of Alaska ARM Comparisons for Snow-Covered Conditions

- Assume surface albedo affecting both surface and satellite retrievals is

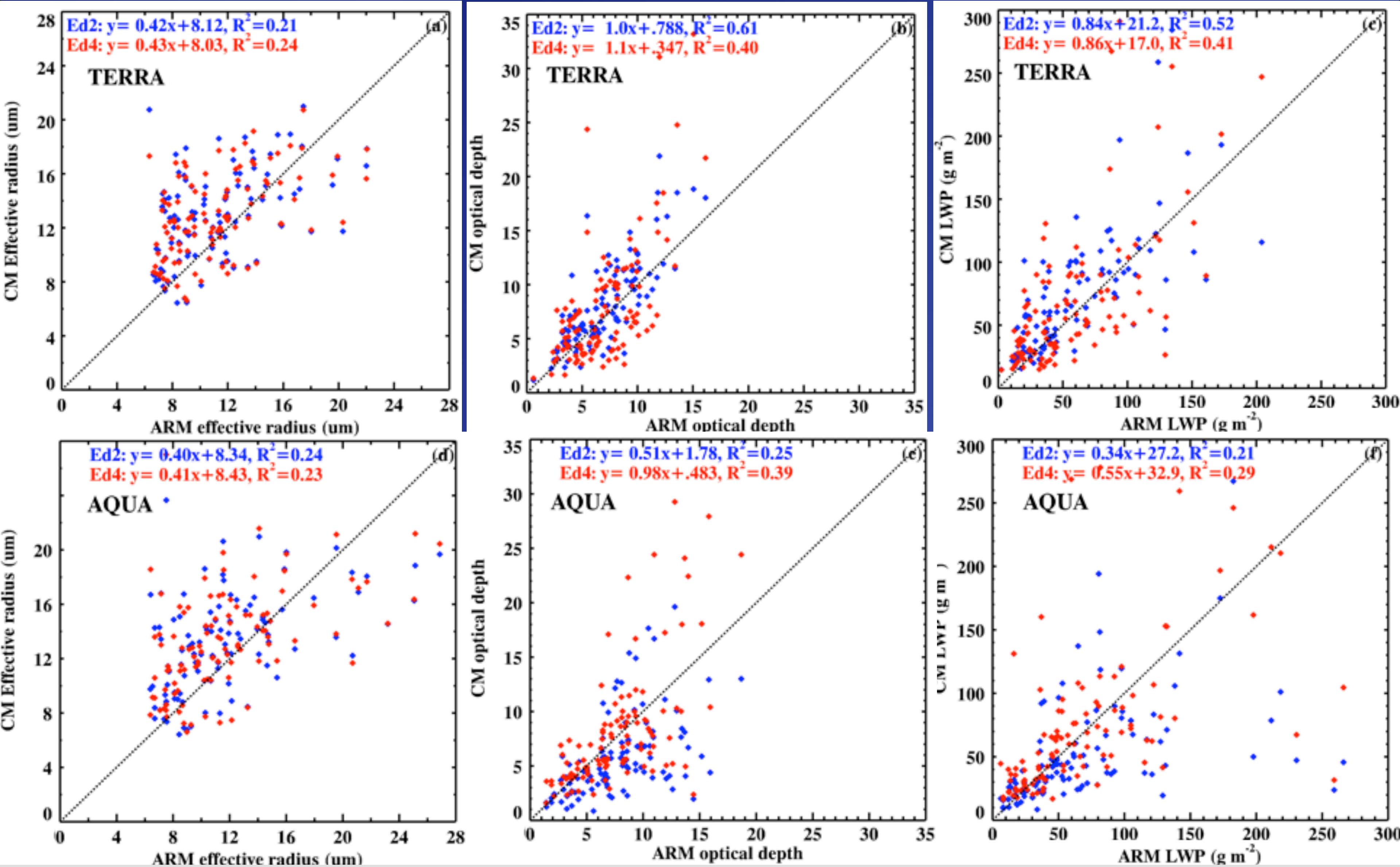
  As = 0.8*Rs, where Rs = albedo measured at ARM site

- SatCORPS uses 1.24-μm channel for COD retrieval

- Surface measurements use MWR and SW radiometers in parameterization

Dong et al., JGR, 2016

Terra and Aqua Ed4 Cloud Properties versus ARM retrievals

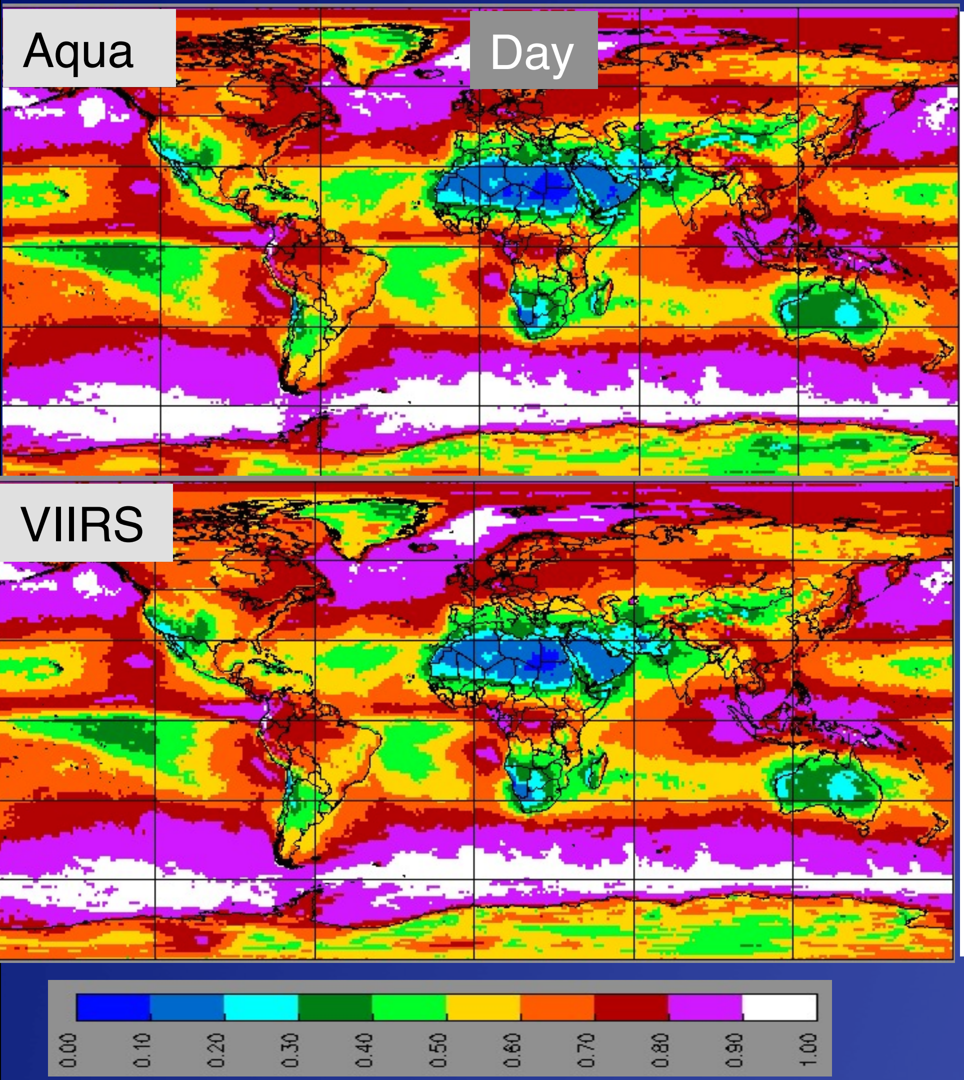


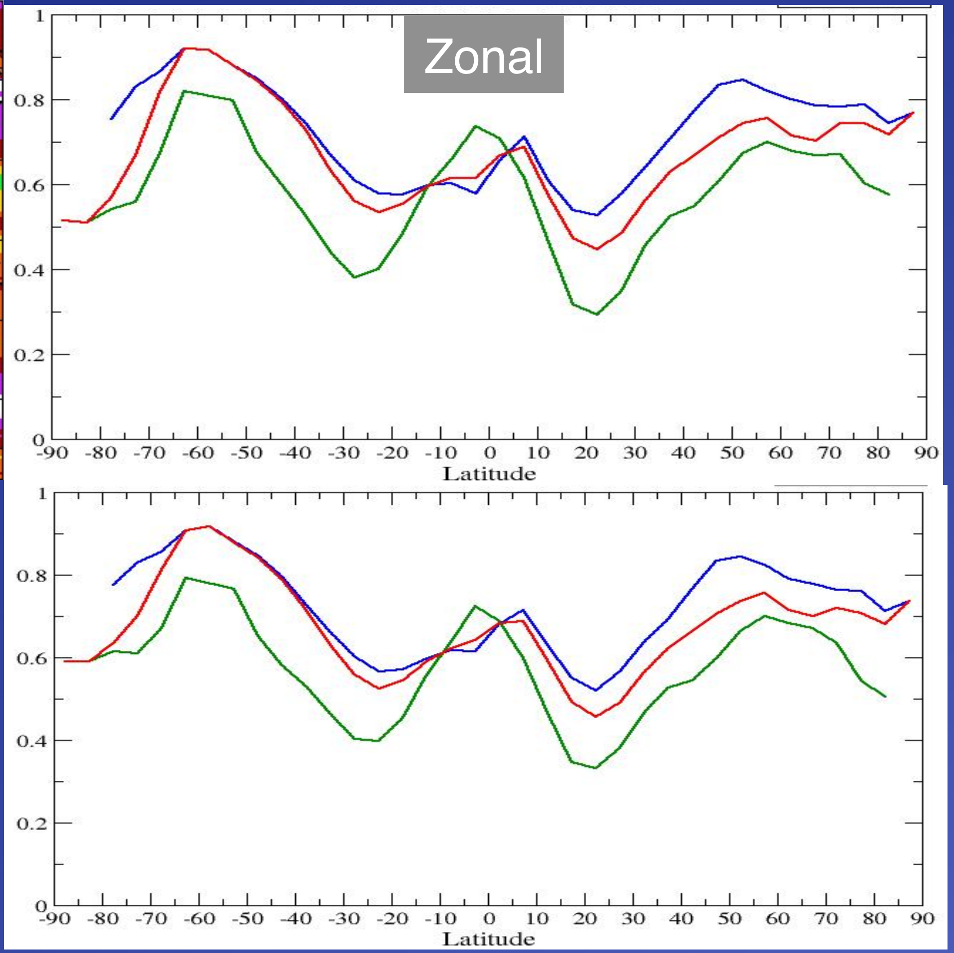
1) Terra: ARM re=11.1 vs. Ed4=12.8 μm, ARM tau=7.1 vs. 7.9, ARM LWP=58.1 vs. 67.0 gm^{-2}
2) Aqua: ARM re=11.7 vs. Ed4=13.2 μm, ARM tau=7.8 vs. 8.2, ARM LWP=69.0 vs. 71.2 gm^{-2}

MEANS
&
VARIATIONS

- VIIRS vs. Aqua MODIS: 2013
- Cloud height and fraction trends

Aqua & VIIRS Daytime Mean Cloud Fraction, 2013

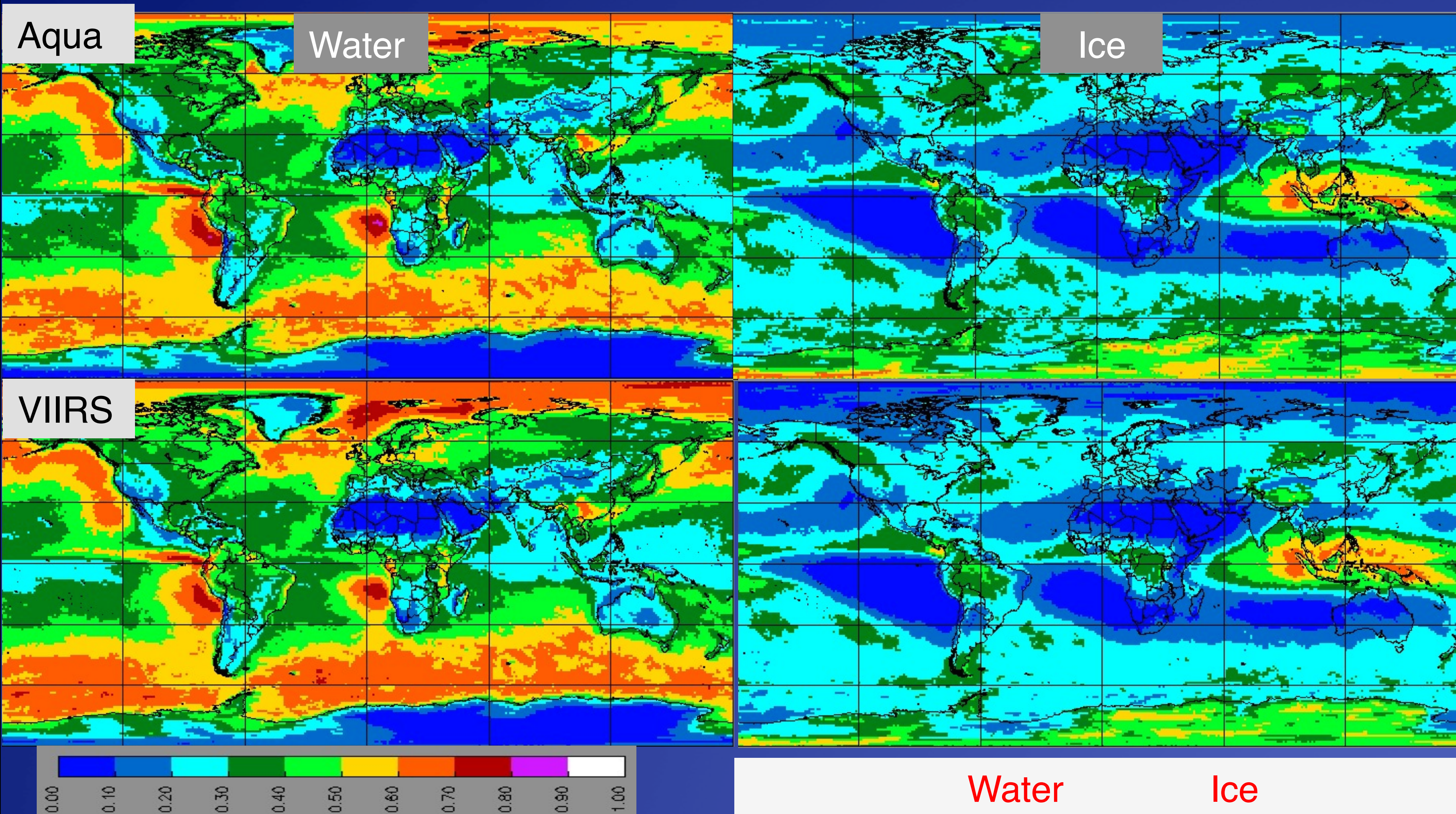




	Aqua	SNPP
Day	0.651	0.652
Night	0.684	0.672

- VIIRS & MODIS very similar in daytime
- Largest differences at night (tropics & Arctic

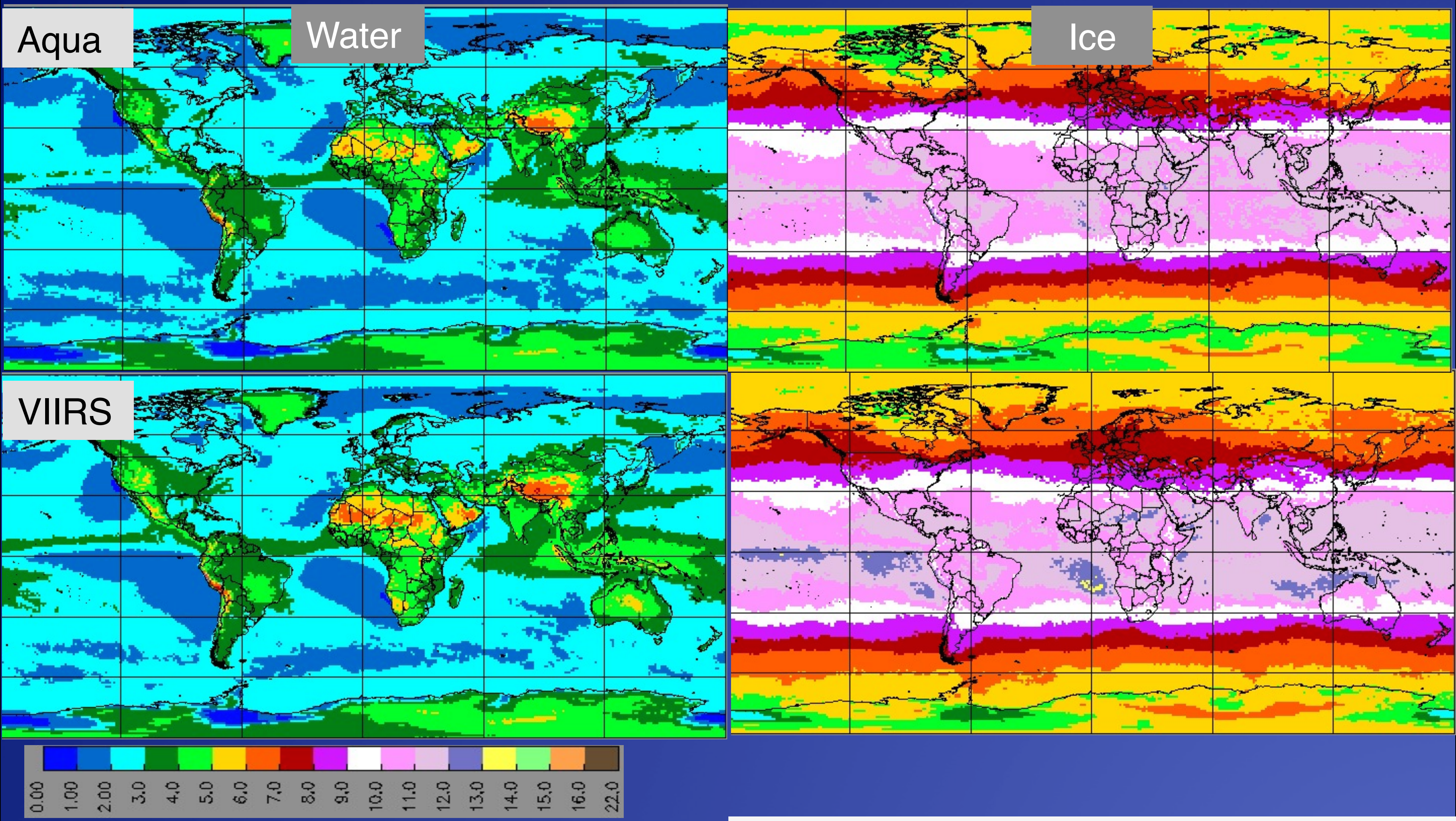
Aqua & VIIRS Daytime Mean Cloud Fraction by Phase, 2013



	Water		Ice	
	Aqua	SNPP	Aqua	SNPP
Day	0.403	0.406	0.247	0.239
Night	0.363	0.357	0.323	0.315

- VIIRS & MODIS phase very consistent day and night

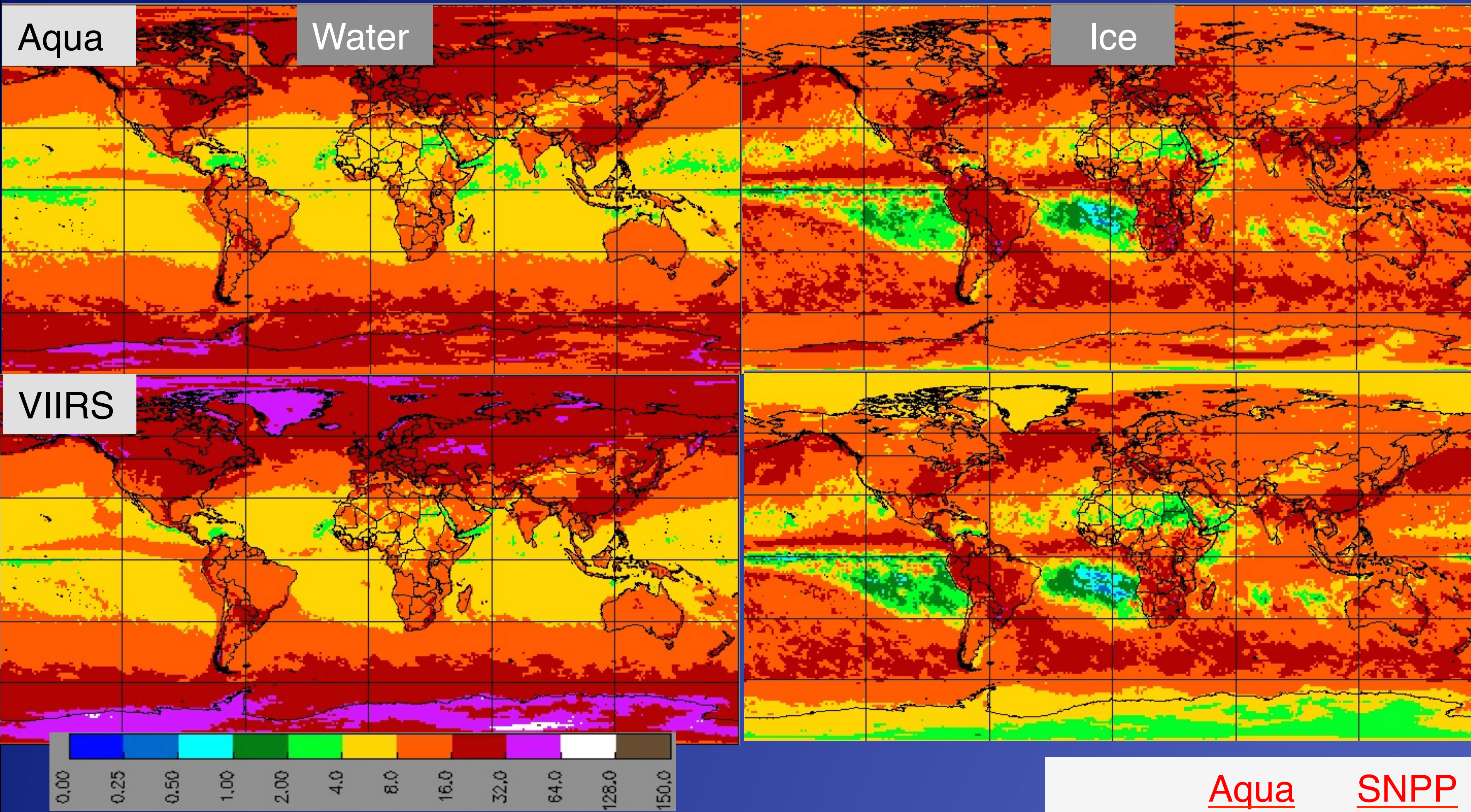
Aqua & VIIRS Mean Cloud Effective Heights (km), 2013



• VIIRS slightly higher than MODIS during the daytime

	Water		Ice	
	Aqua	SNPP	Aqua	SNPP
Day	2.66	2.84	8.80	9.14
Night	2.93	3.01	9.42	9.43

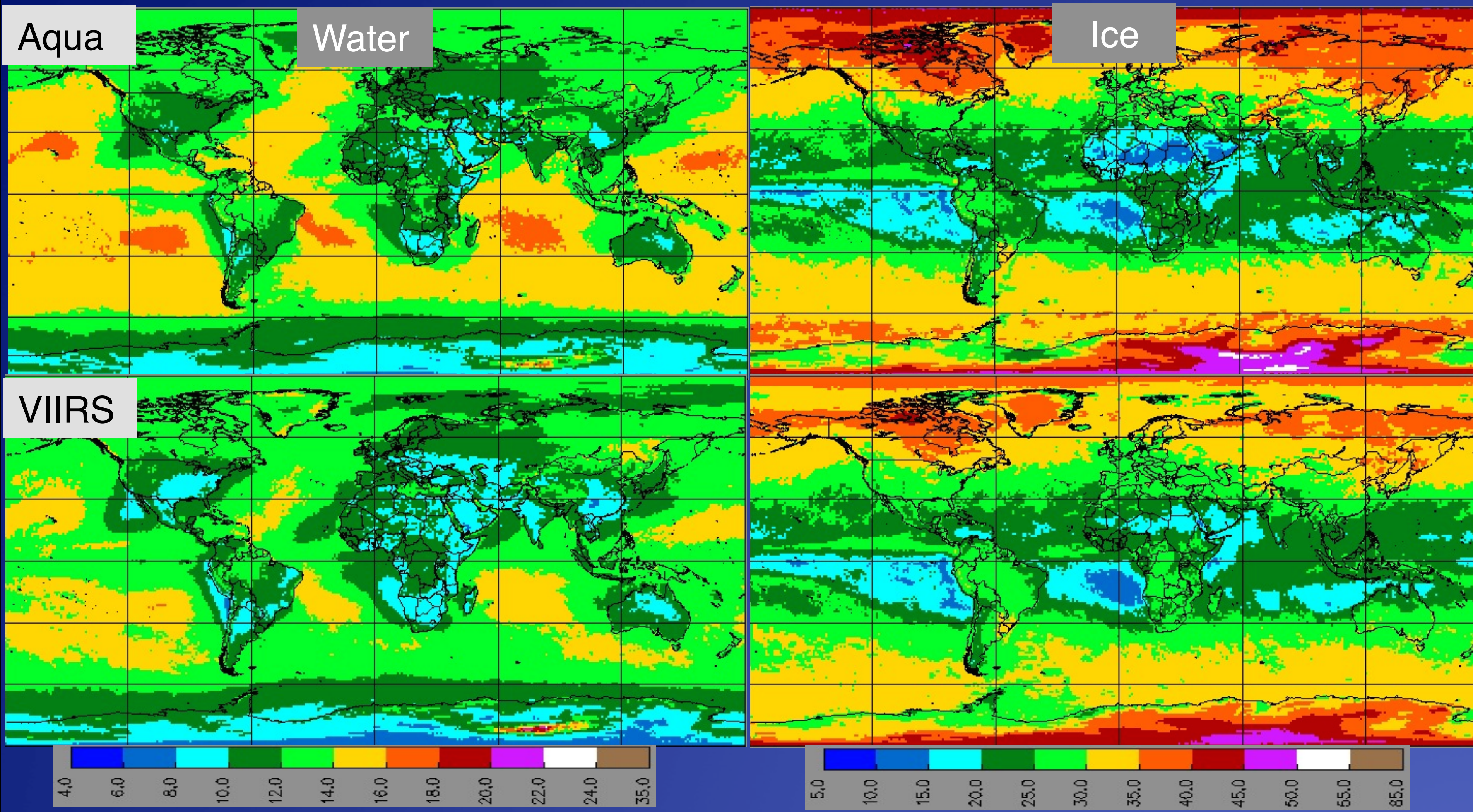
Aqua & VIIRS Mean Cloud Optical Depths, Day 2013



- VIIRS larger for water, resolution effect?
- VIIRS ice both smaller & larger, 10% less in mean

	Aqua	SNPP
Water	11.0	13.2
Ice	12.8	11.6

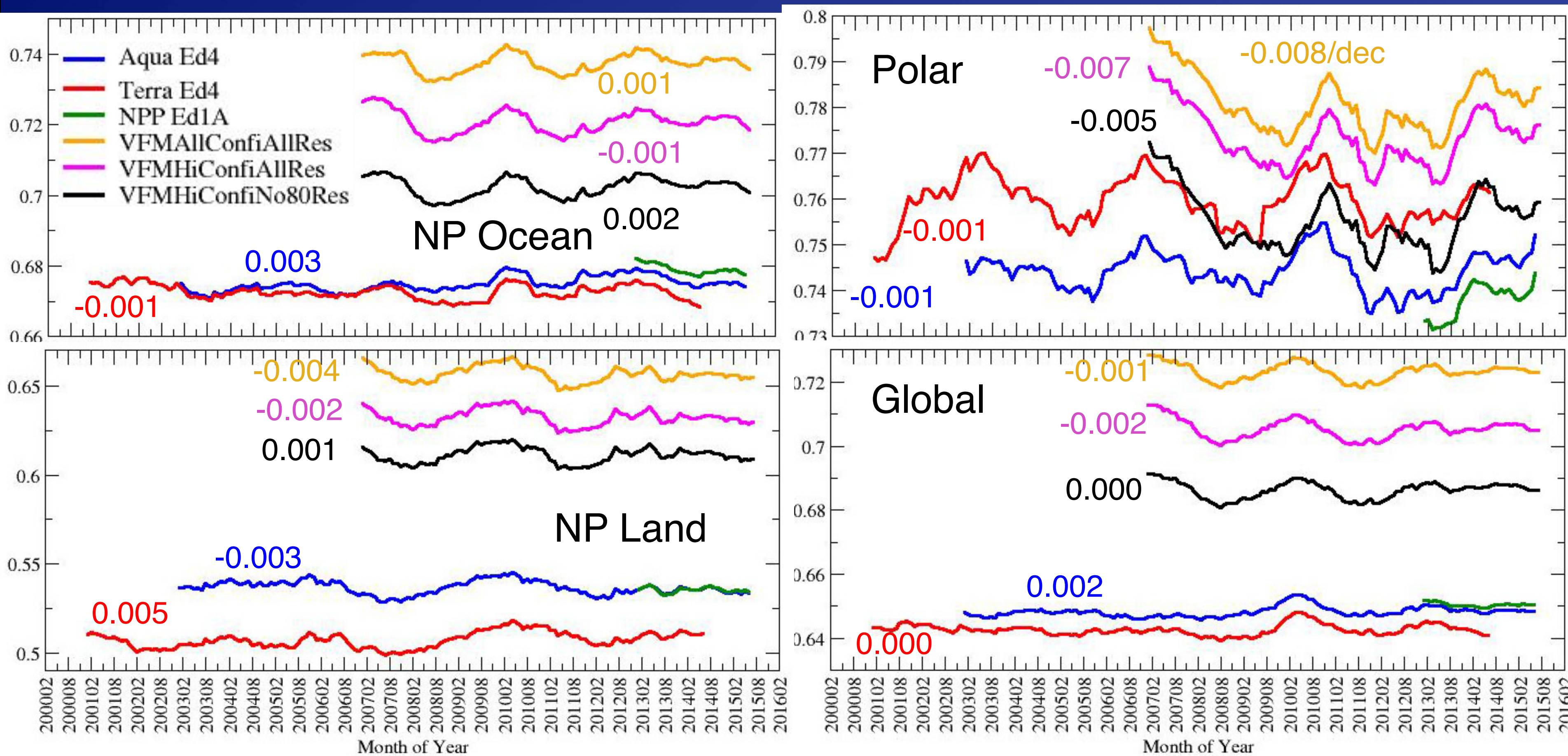
Aqua & VIIRS Mean Cloud Effective Radius (μm), Day 2013



- VIIRS water smaller everywhere, new model
- VIIRS ice wee bit smaller

	Aqua	SNPP
Water	13.4	12.4
Ice	27.0	26.7

Mean Daytime Cloud Fraction Trends (/decade)
CERES MODIS, CALIPSO, 2000-2015

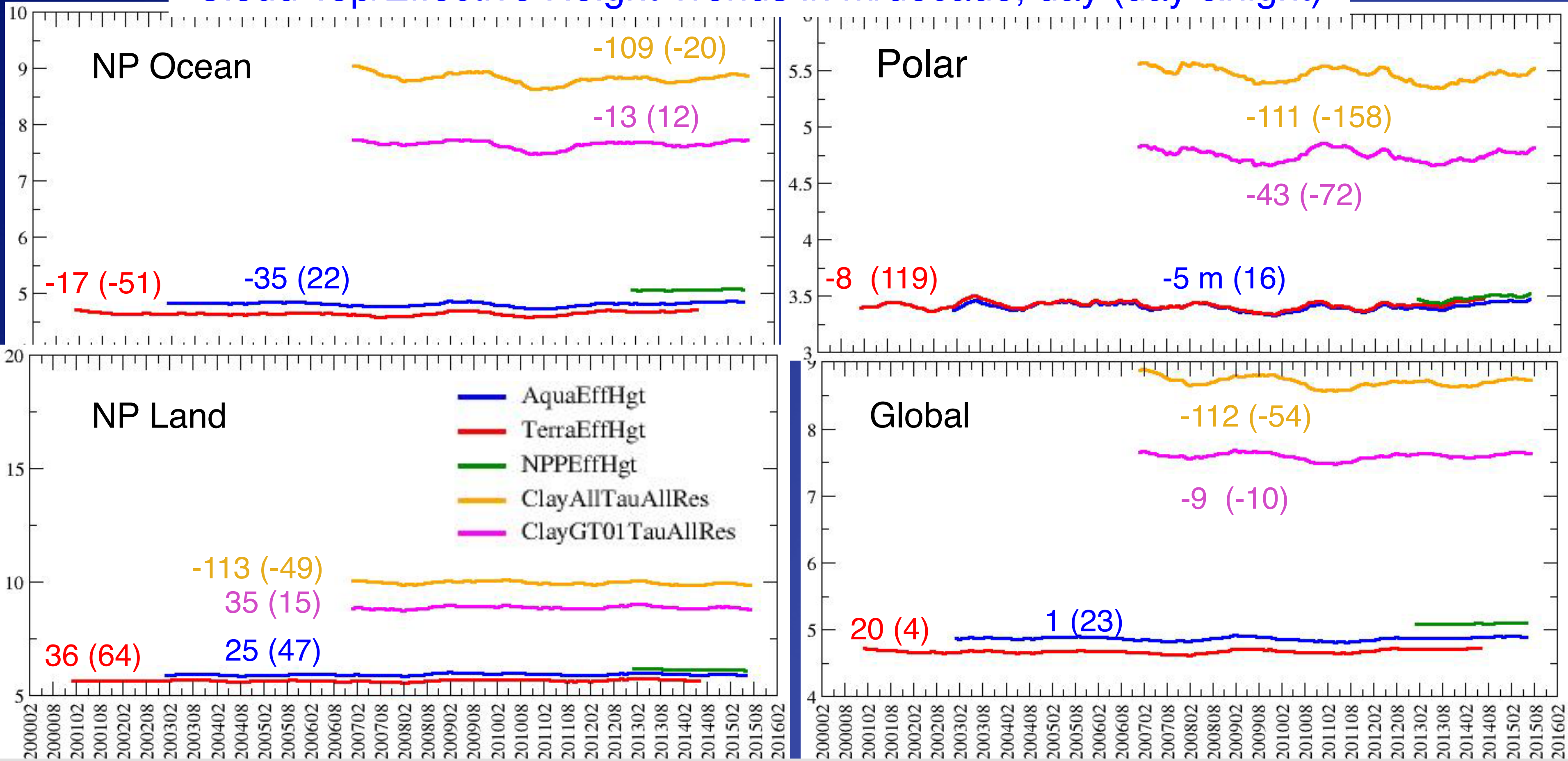


- Weak negative trends in CERES & CALIPSO cloud fractions over polar regions
  - *at night, no trends seen in CALIPSO; CERES shows strong negative*
- Essentially no global trends in day cloud fraction since 2000
  - *at night, small positive trend in CALIPSO; CERES with small negative*

Mean Daytime Global Cloud Effective Height Trends

CERES & CALIPSO (2000-2015)

Cloud Top/Effective Height Trends in m/decade, day (day &night)



- MODIS: Negative trends in day, NP ocean; positive or nil for other surfaces
- CALIPSO negative globally for 2006-2015, day and night, except thick clouds over land
  - short term trend of decreasing cloud height for thin clouds probably real (gold)
  - *results suggests cloud radiating temperature increased by ~0.05 – 0.10 K/dec over last decade based on Γ = 6.5 K/km*

CERES GEOSat Cloud Properties

- LaRC calibration team found the degradation rates of the active GEOSAT IR sensors (GOES-13, GOES-15, MET-10) changed since 2014
  - CERES-TISA geostationary version of SATCORPS calibration modules were updated, tested and redelivered to the TISA group

- HIMAWARI-8 test code and dataset for Oct 2015 provided for dry run to test the different processes and scripts in making the SYN 1deg products

- Mask improvements

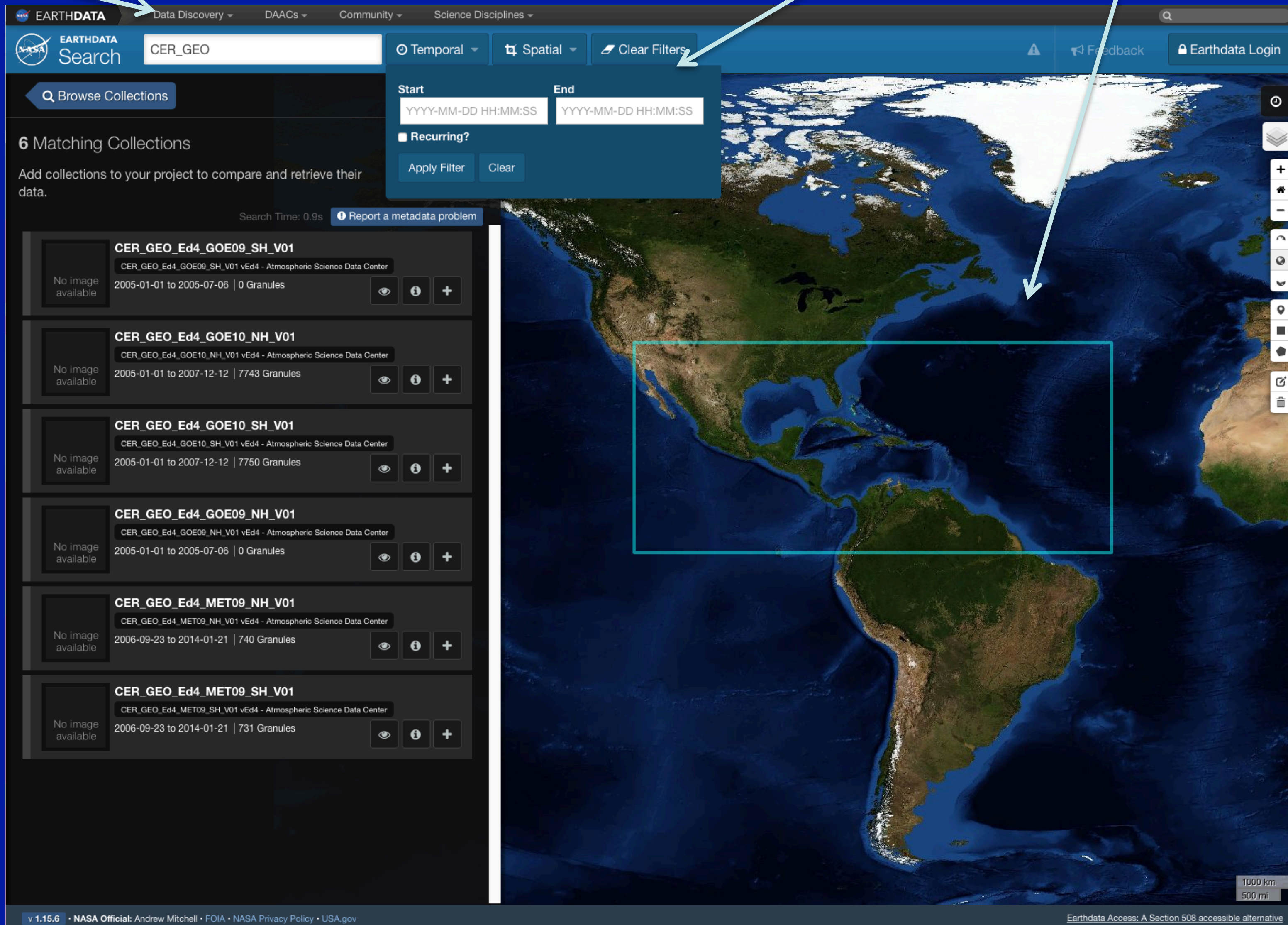
- Retrieval adjustments

CERES GEO pixel Level 2 dataset (June 2005 – Dec 2014) available at the ASDC- DAAC through NASA's Earthdata website :

https://search.earthdata.nasa.gov

Tool allows data to be ordered by temporal range and/or spatial domain

Type "CER_GEO" in the search box



Cloud Mask Update for Himawari-8 (H8)

Added Satellite ID to separate Himawari with Met 10

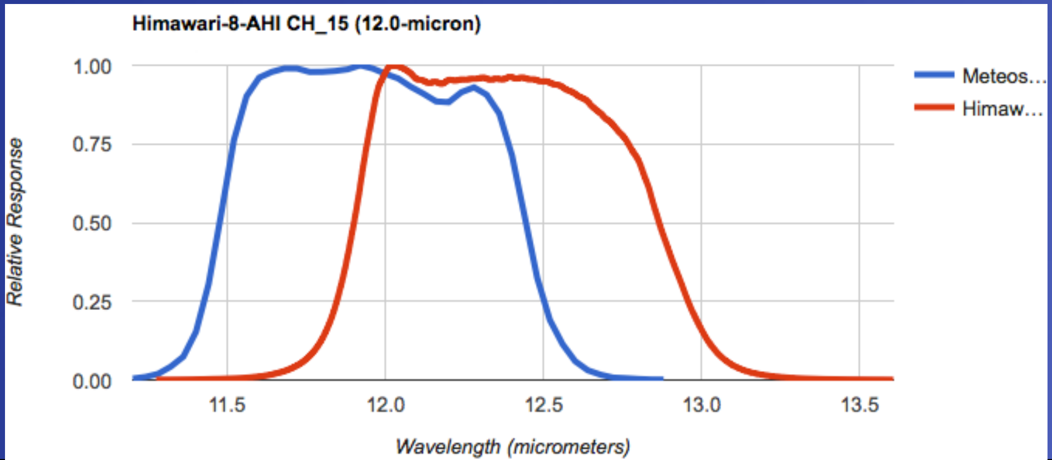
- Himawari data use same flow as Terra, VIIRS, and MSG, using 1.6, not 2.3 μm
- MSG and Himawari use Terra MODIS Polar Daytime/Twilight Masks
- Applied MSG snow detection to Himawari, differs from MODIS & VIIRS

Improved daytime cloud mask

- Refined low clouds detection over ocean
- Reduced chunky clouds along Australia coasts

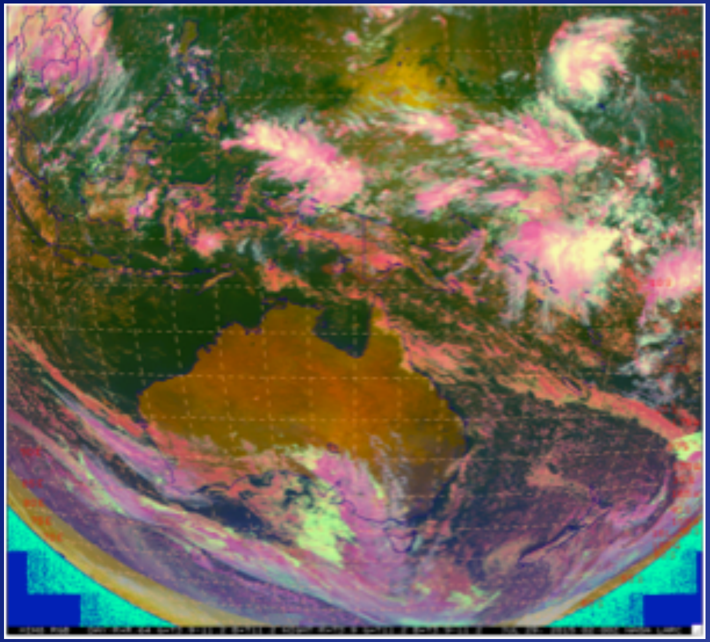
Improved nighttime mask

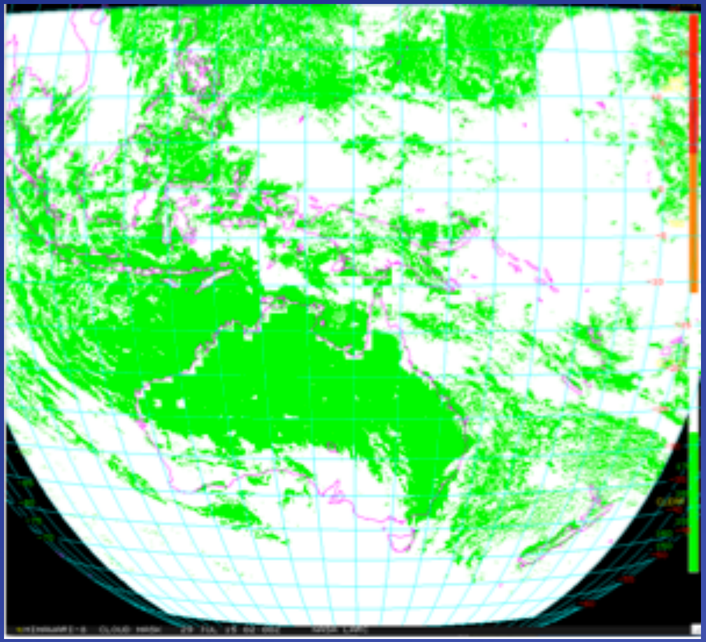
- Reduced false clouds over Australia desert
- Reduced questionable thin Cirrus clouds over ocean and land due to T12



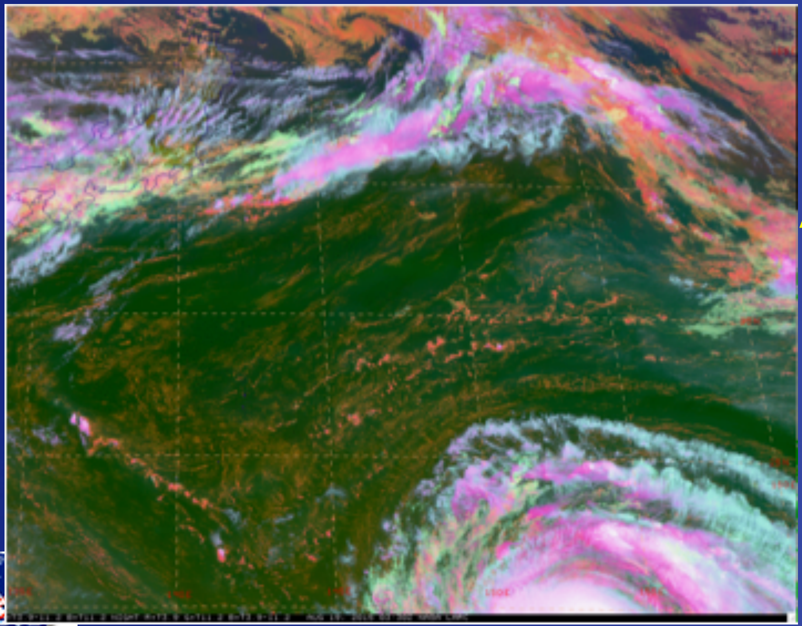
Himawari Daytime Improvements

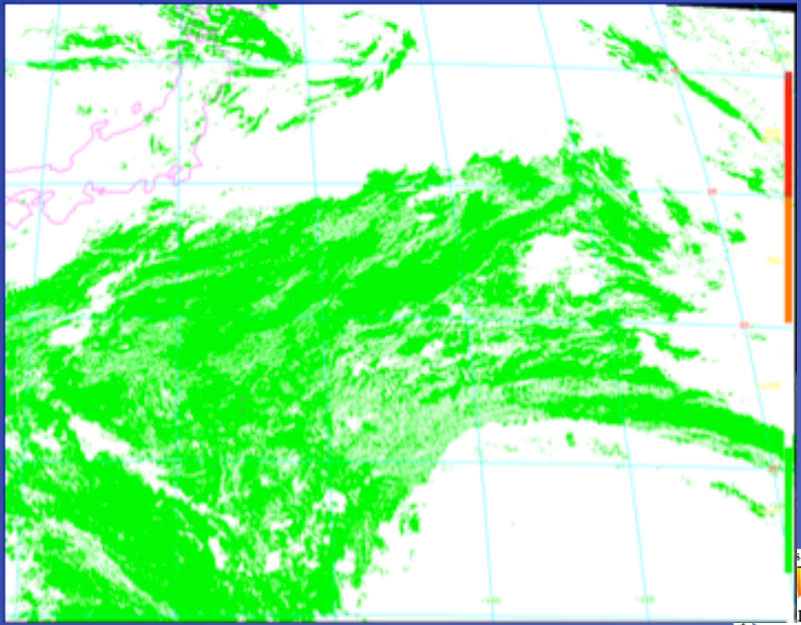
Before





Jul 29, 2015 0200

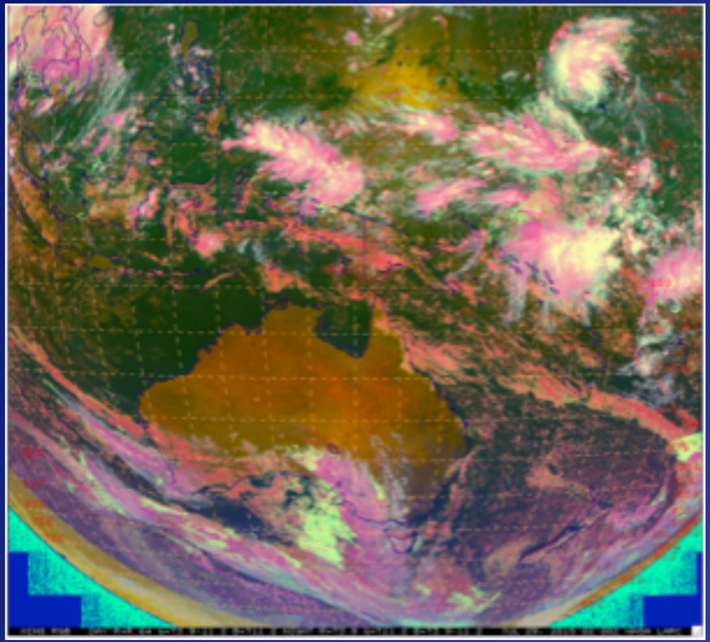


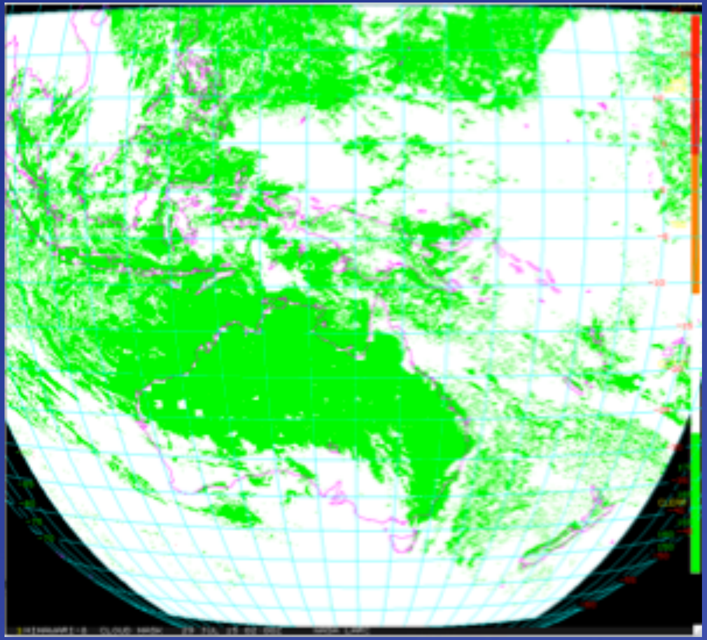


Aug 19, 2015 0300

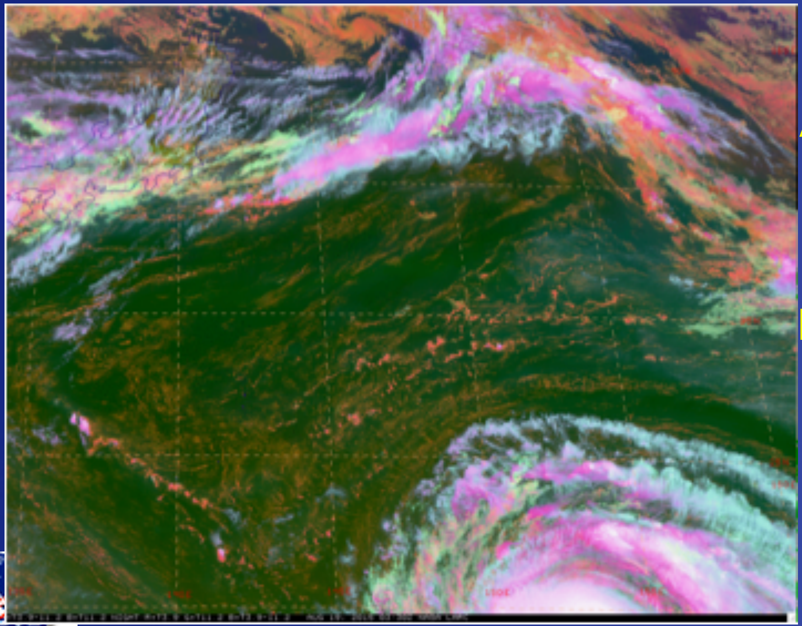
After

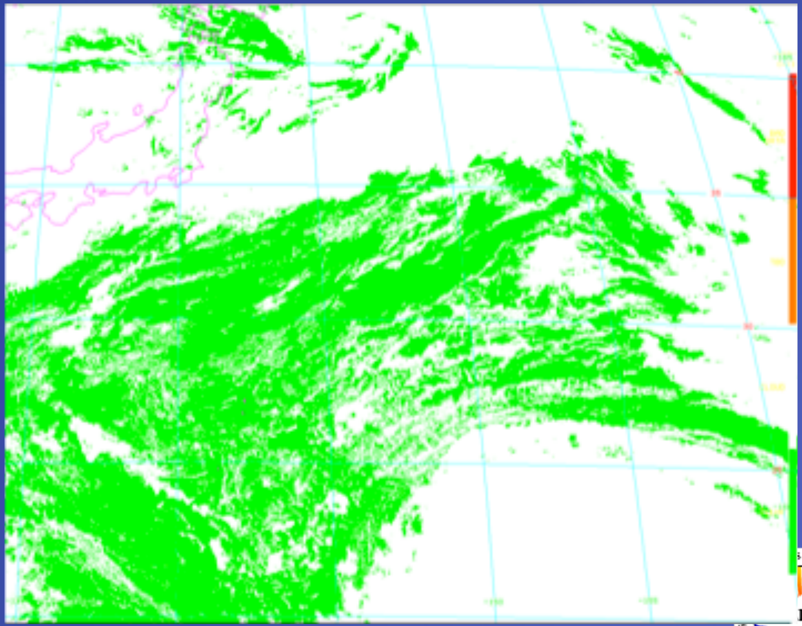
Himawari Daytime Improvements





Jul 29, 2015 0200
Reduce coastal chunky clouds



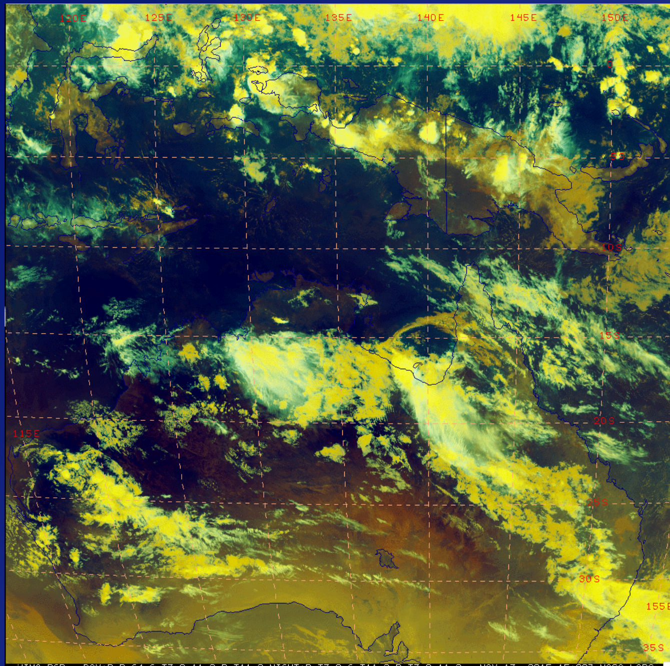


Aug 19, 2015 0300

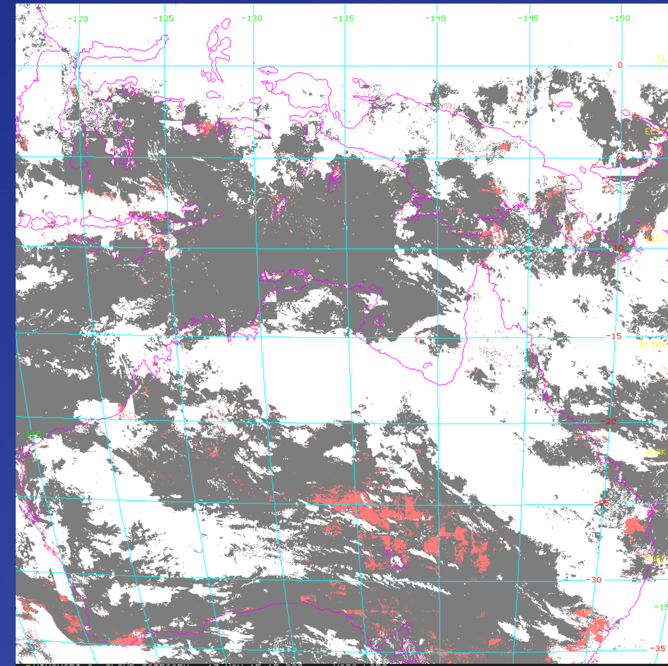
Increase ocean low clouds

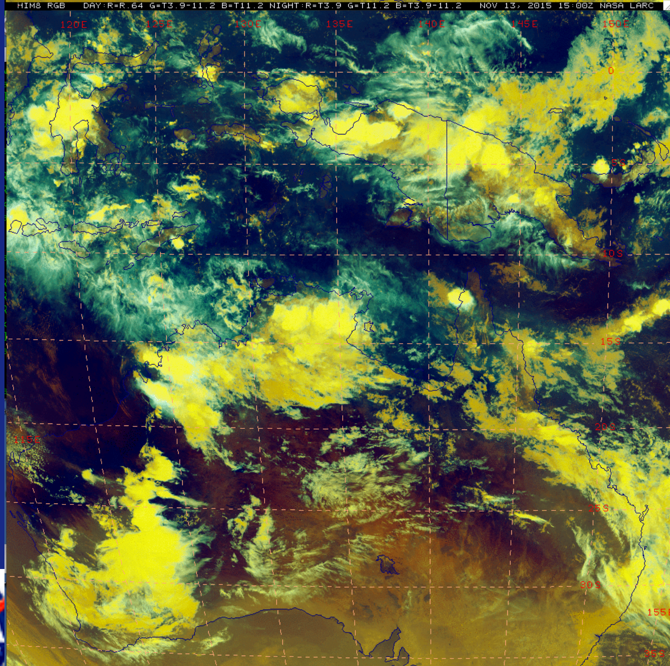
Himawari – Reduced Desert False Clouds

Before

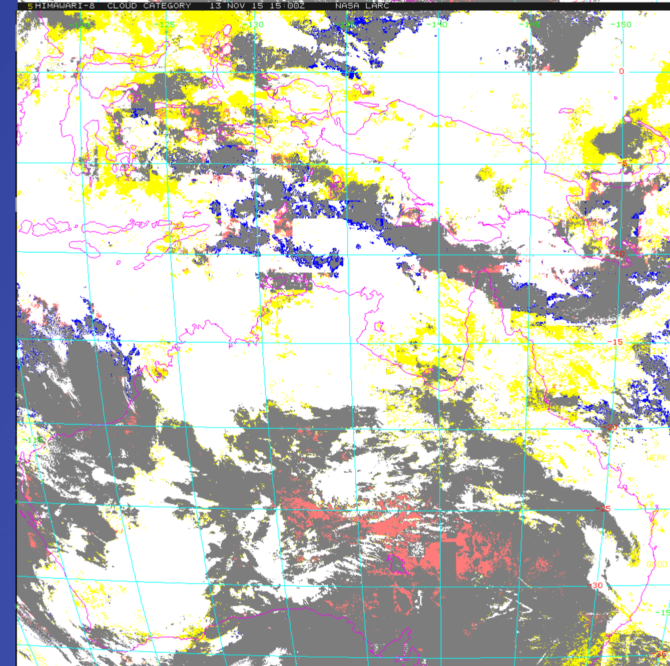


Nov 13, 2015 1500 Z



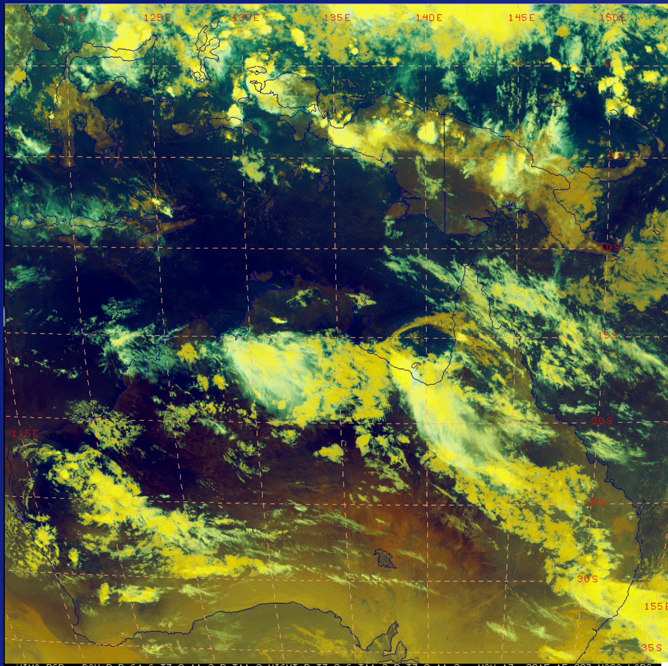


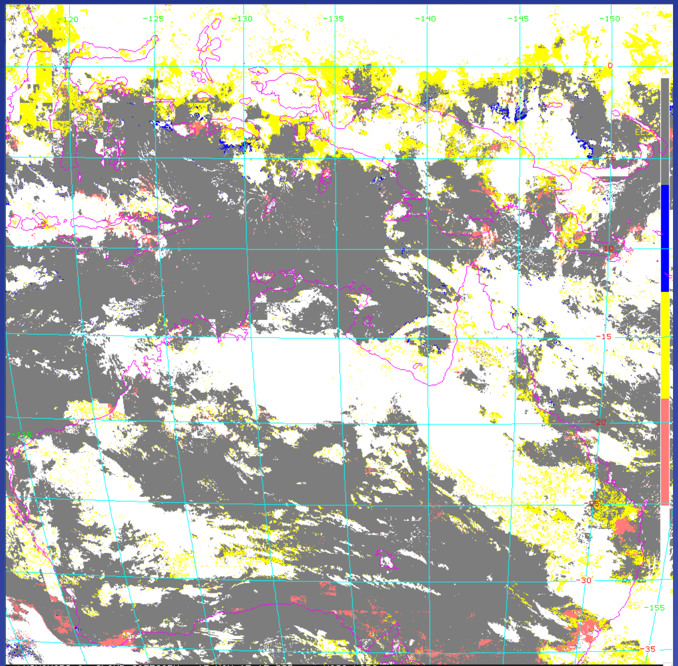
Dec 2, 2015 1300 Z



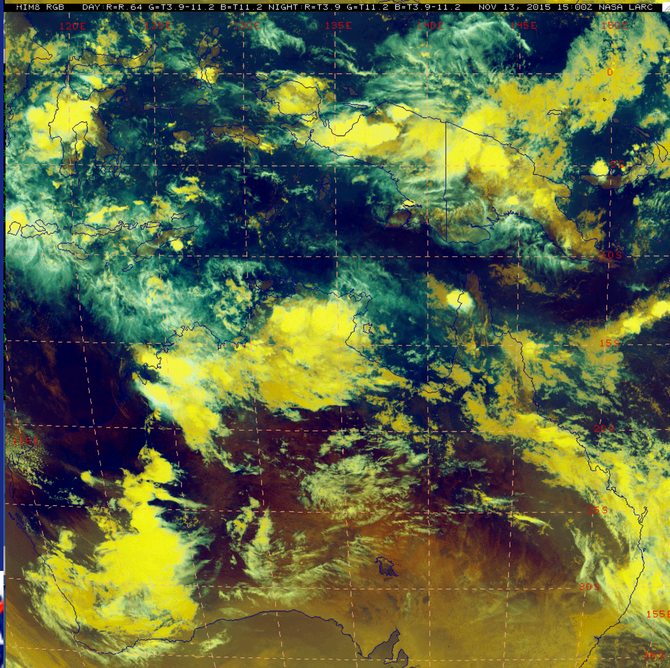
After

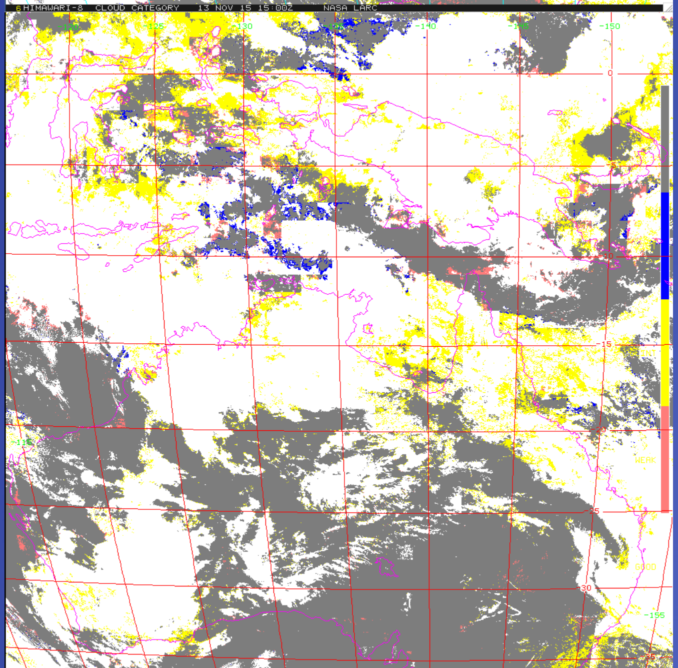
Himawari – Reduced Desert False Clouds





Nov 13,
2015
1500 Z



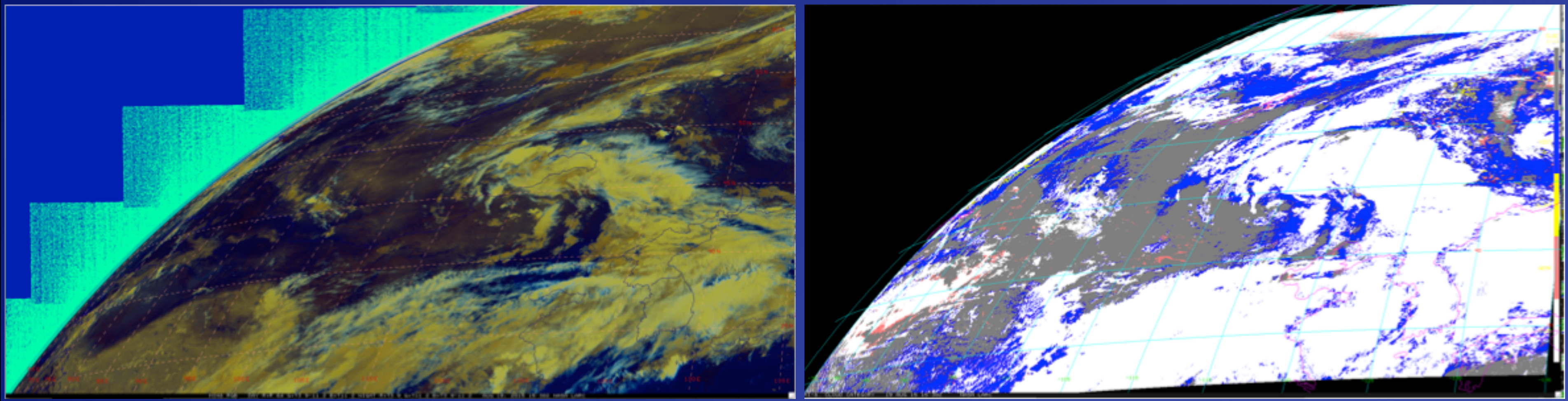


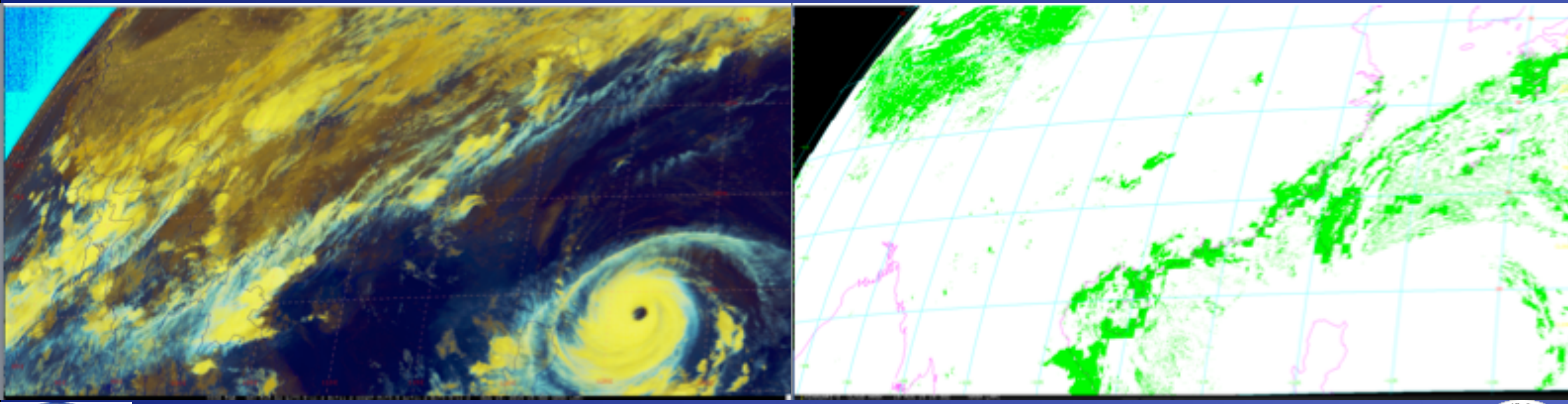
Dec 2,
2015
1300 Z

Himawari – Reduced false clouds over land and ocean

Aug 19, 2015 1530

Before

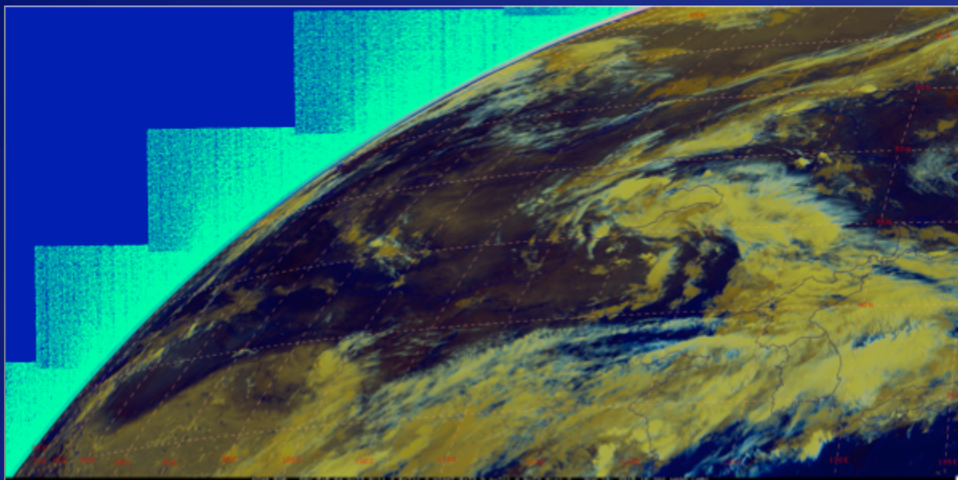


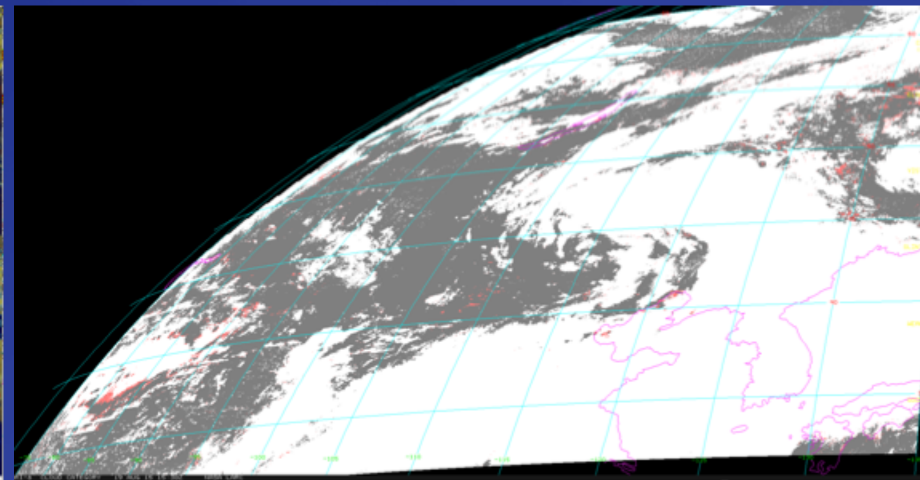


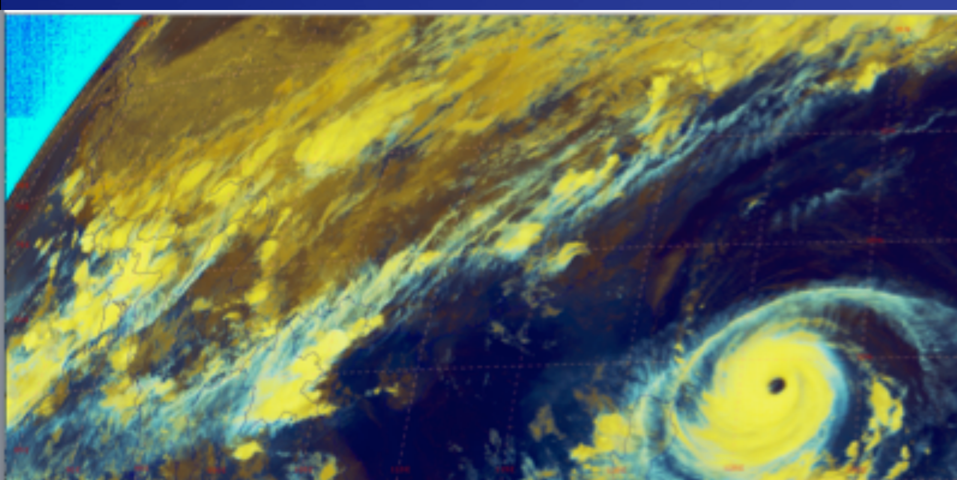
Himawari – Reduced false clouds over land and ocean

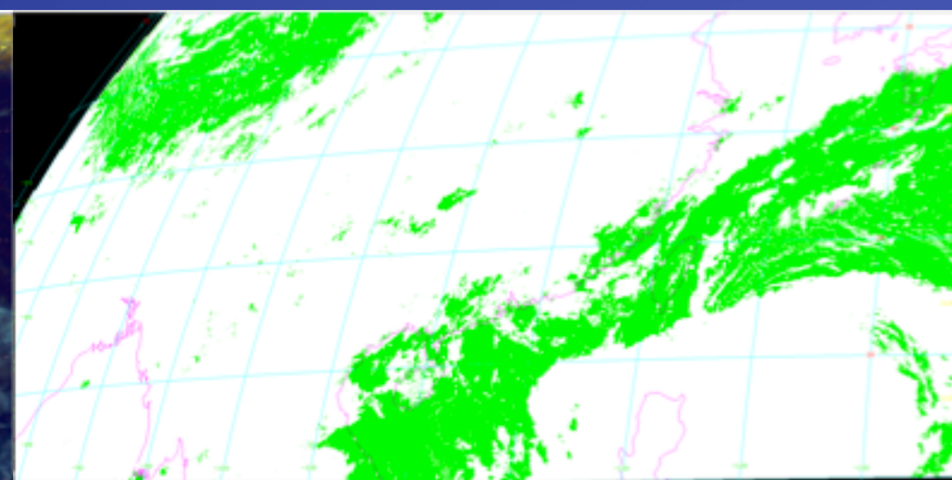
Aug 19, 2015 1530

After









Summary of Mask Comparison With CALISPO

```
CALIPSO-GEO.MASK.OCEAN.txt - /CLOUDS/cyost/GEO/validation/contabs/
File  Edit  Search  Preferences  Shell  Macro  Windows  Help
'S/cyost/GEO/validation/contabs/CALIPSO-GEO.MASK.OCEAN.txt 2421 bytes  L: 1  C: 0

====================== 0 < SZA < 180 (all) ======================
                              CALIPSO
                        CLEAR              CLOUD            TOTALS
   GEO   CLEAR     811 ( 15.0%)     349 (  6.5%)    1160 ( 21.5%)
         CLOUD     278 (  5.2%)    3958 ( 73.4%)    4236 ( 78.5%)

        TOTALS    1089 ( 20.2%)    4307 ( 79.8%)    5396 (100.0%)

     FC  = 0.884        H = 0.919      FAR = 0.066
     CSI = 0.863        B =  0.98      HSS =  0.65

======================= SZA < 82.0 (day) =======================
                              CALIPSO
                        CLEAR              CLOUD            TOTALS
   GEO   CLEAR     663 ( 18.1%)     278 (  7.6%)     941 ( 25.6%)
         CLOUD     193 (  5.3%)    2539 ( 69.1%)    2732 ( 74.4%)

        TOTALS     856 ( 23.3%)    2817 ( 76.7%)    3673 (100.0%)

     FC  = 0.872        H = 0.901      FAR = 0.071
     CSI = 0.844        B =  0.97      HSS =  0.65

====================== SZA > 82.0 (night) ======================
                              CALIPSO
                        CLEAR              CLOUD            TOTALS
   GEO   CLEAR     148 (  8.6%)      71 (  4.1%)     219 ( 12.7%)
         CLOUD      85 (  4.9%)    1419 ( 82.4%)    1504 ( 87.3%)

        TOTALS     233 ( 13.5%)    1490 ( 86.5%)    1723 (100.0%)

     FC  = 0.909        H = 0.952      FAR = 0.057
     CSI = 0.901        B =  1.01      HSS =  0.60
```

```
CALIPSO-GEO.MASK.LAND.txt - /CLOUDS/cyost/GEO/validation/contabs/
File  Edit  Search  Preferences  Shell  Macro  Windows  Help
DS/cyost/GEO/validation/contabs/CALIPSO-GEO.MASK.LAND.txt 2421 bytes  L: 1  C: 0

====================== 0 < SZA < 180 (all) ======================
                              CALIPSO
                        CLEAR              CLOUD            TOTALS
   GEO   CLEAR     811 ( 36.8%)     109 (  4.9%)     920 ( 41.7%)
         CLOUD      71 (  3.2%)    1214 ( 55.1%)    1285 ( 58.3%)

        TOTALS     882 ( 40.0%)    1323 ( 60.0%)    2205 (100.0%)

     FC  = 0.918        H = 0.918      FAR = 0.055
     CSI = 0.871        B =  0.97      HSS =  0.83

======================= SZA < 82.0 (day) =======================
                              CALIPSO
                        CLEAR              CLOUD            TOTALS
   GEO   CLEAR     503 ( 31.7%)      85 (  5.4%)     588 ( 37.1%)
         CLOUD      34 (  2.1%)     965 ( 60.8%)     999 ( 62.9%)

        TOTALS     537 ( 33.8%)    1050 ( 66.2%)    1587 (100.0%)

     FC  = 0.925        H = 0.919      FAR = 0.034
     CSI = 0.890        B =  0.95      HSS =  0.84

====================== SZA > 82.0 (night) ======================
                              CALIPSO
                        CLEAR              CLOUD            TOTALS
   GEO   CLEAR     308 ( 49.8%)      24 (  3.9%)     332 ( 53.7%)
         CLOUD      37 (  6.0%)     249 ( 40.3%)     286 ( 46.3%)

        TOTALS     345 ( 55.8%)     273 ( 44.2%)     618 (100.0%)

     FC  = 0.901        H = 0.912      FAR = 0.129
     CSI = 0.803        B =  1.05      HSS =  0.80
```

- 87.2%, 92.5% fraction correct over ocean, land in daytime
- 90.9%, 90.1% fraction correct over ocean, land at night
- Preliminary result for two overpasses, 0330/1530 UTC, 19 August 2015
- Additional comparisons to be done

Himiwari-8 Retrievals

No Retrievals

• Initial runs yield reasonable results, but > 10% cloud pixels give no retrieval

- wreaks havoc on computed TOA fluxes

• Developed new interpolation codes to fill no retrievals and other defaults

- assumes average Re for given level (default otherwise)

- computes tau and Tcld

• Apply fixed-Re SIST for no retrievals of obvious cirrus clouds

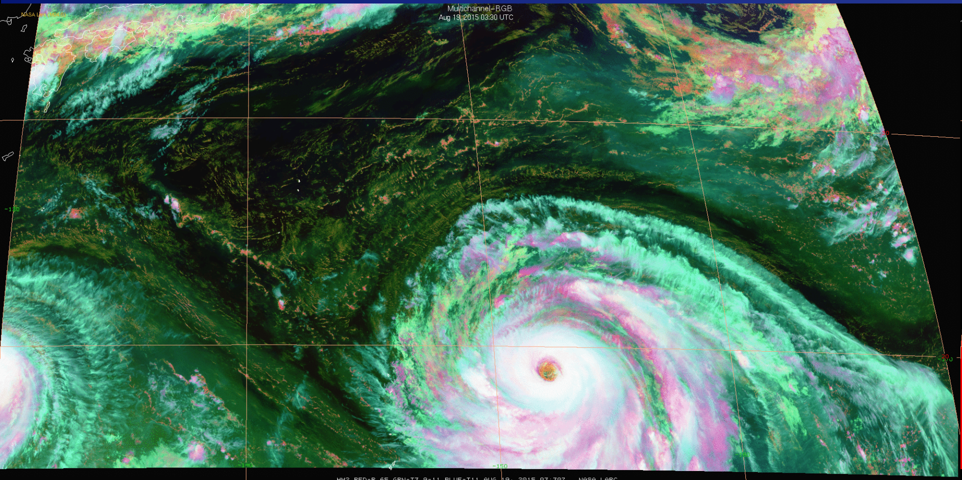
- assumes Re and uses 11 and 12 µm channels only

• Delivery this week

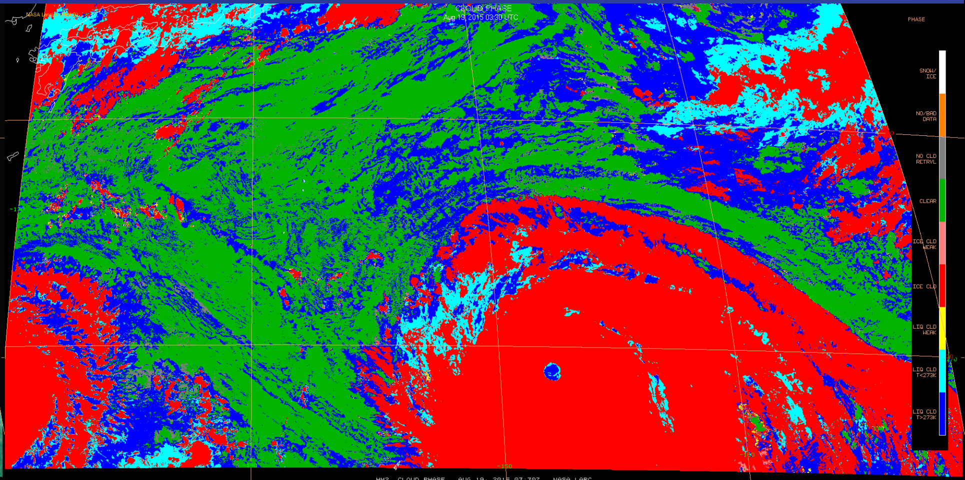
Himwari-8 Cloud Properties

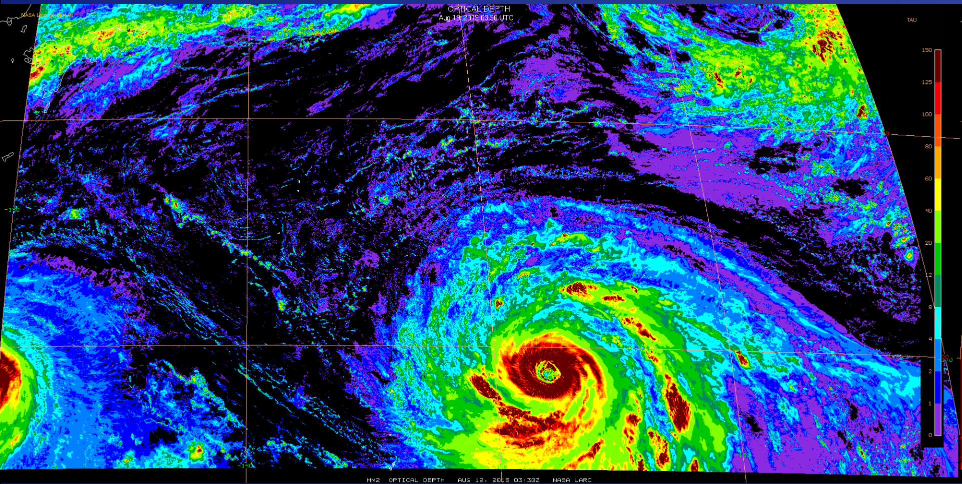
0330 UTC, 19 August 2015

RGB

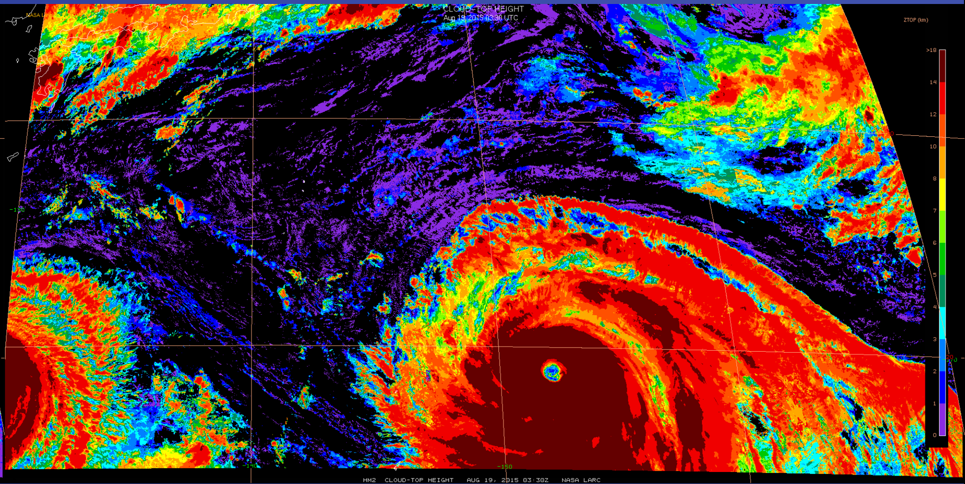


Phase



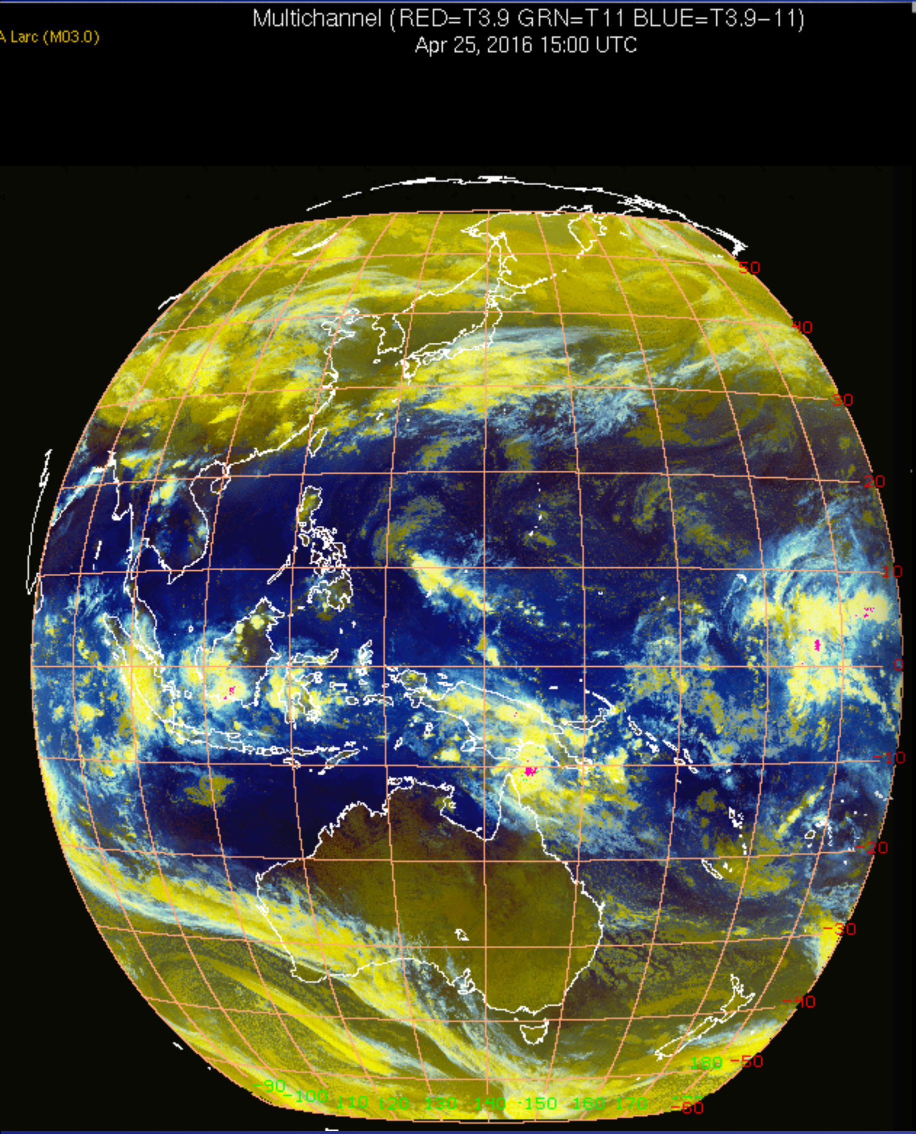


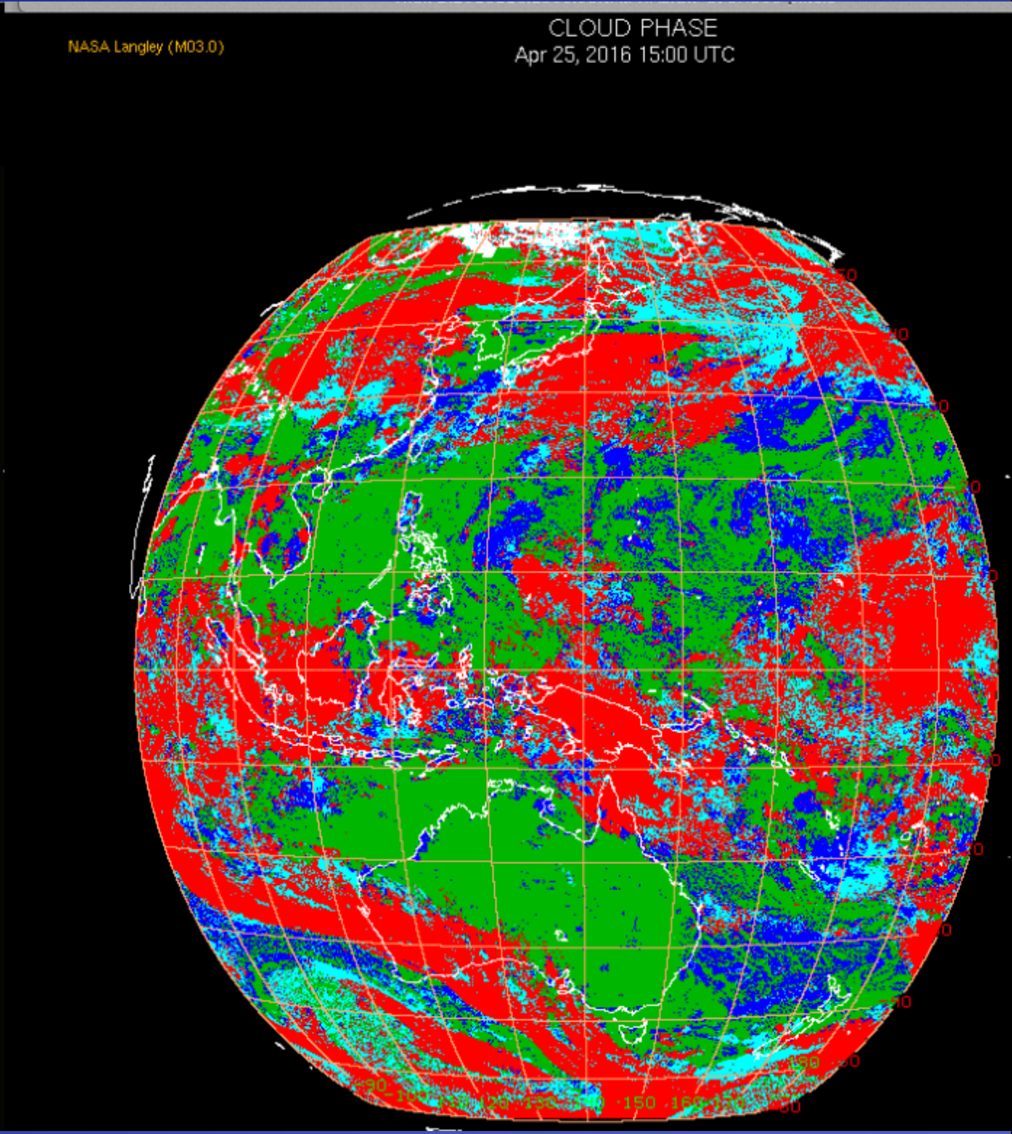
COD



Ztop

Himiwari-8 Cloud Phase, 1500 UTC, 25 April 2016





Toward Edition 5

- Use MODIS Collection 6 calibrations
  - *improve front end of Terra VIS and maybe later A/T VIS*
  - *remove variations in Terra 3.7 & possible 11/12-μm calibration shortcomings*

- Employ new 2-Habit model from P. Yang for ice clouds
  - testing still underway

- Revised algorithms for 1.24, 1.6, and 2.1 *μ*m retrievals
  - *optimal multi-channel algorithm for cloud/snow retrievals*

- Nighttime ice cloud optical depths from neural network

- Improving multi-layer algorithms

- Surface skin temperature

MODIS Collection 5 vs. Collection 6

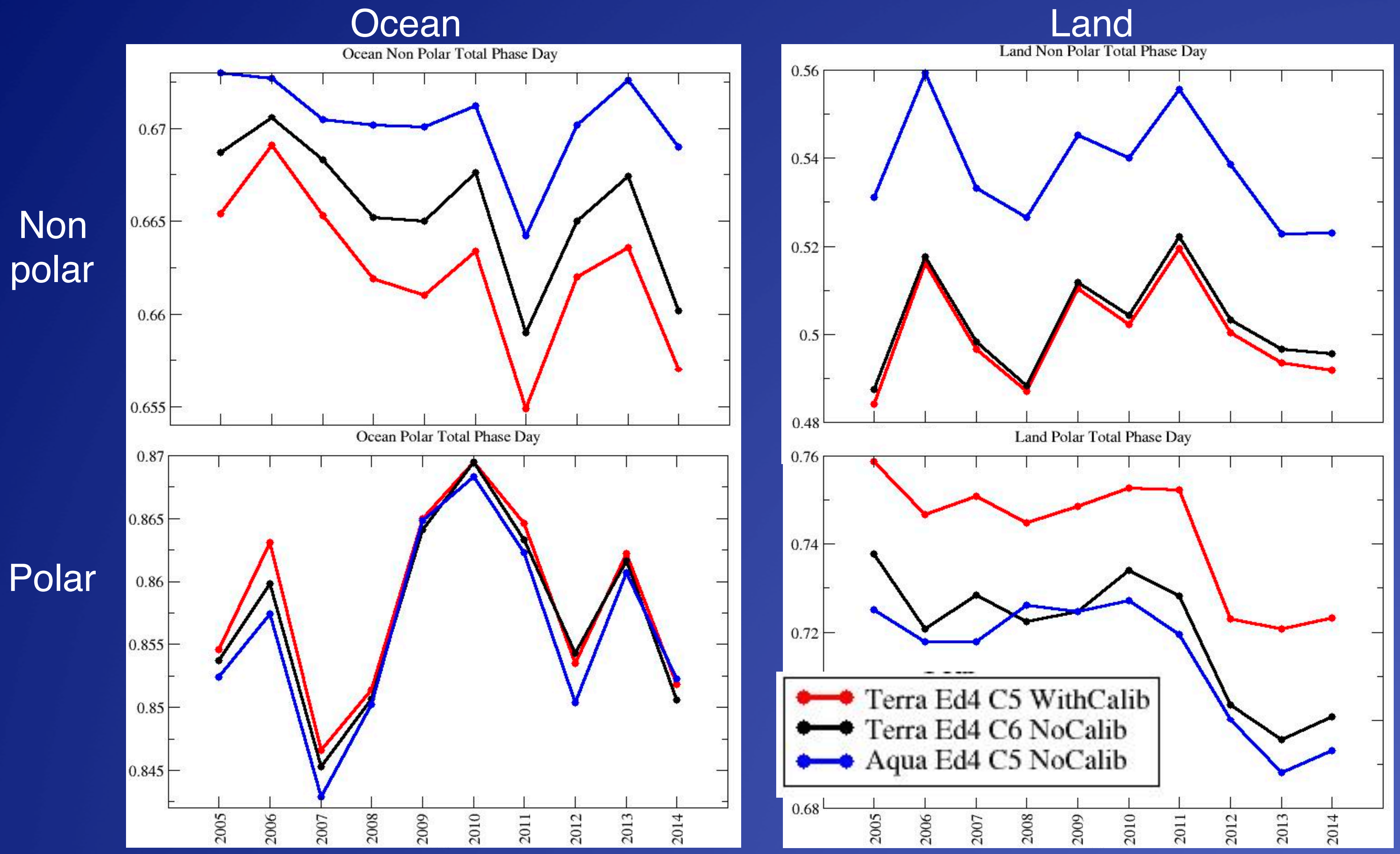
Analyze using C6 with current algorithms and compare with

1) Collection 5 w/o CERES calibrations applied

2) Collection 5 with CERES calibrations applied
   - Terra VIS channel normalization to Aqua
      - *Aqua assumed stable*
   - Terra 3.8-μm normalization to Aqua
      - *night has large effect*
      - *day small Re effect*
   - All other channels assumed to be fine

3) Use only Oct data from 2005 - 2014

Day Cloud Fraction from MODIS C5 and C6, October 2005-2014



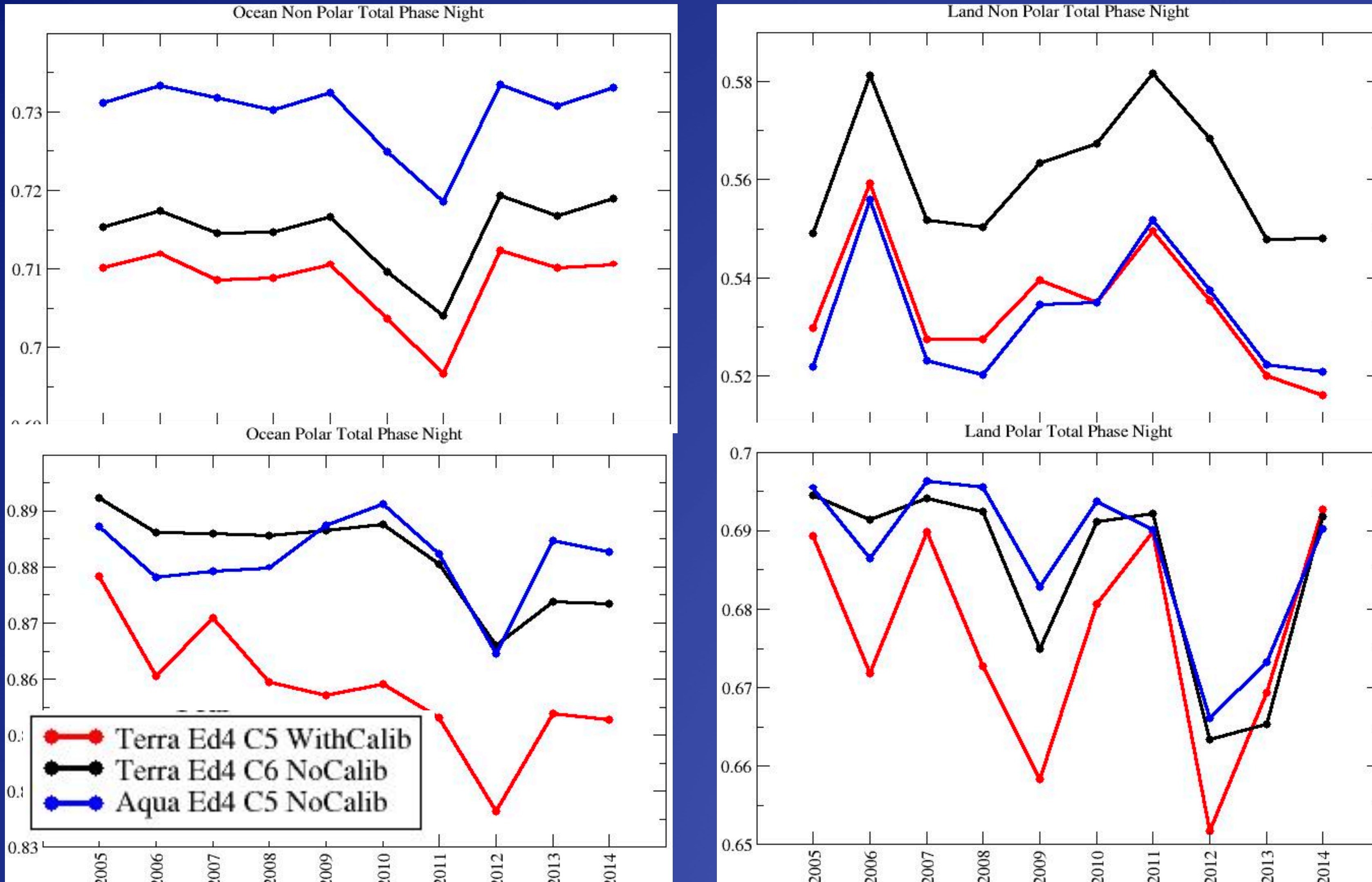
- NP cloud fraction increased ~0.005 over ocean and land
- Better consistency with Aqua over polar regions (other channel calibs)

Night Cloud Fraction from MODIS C5 and C6, October 2005-2014

Ocean | Land

Non polar

Polar



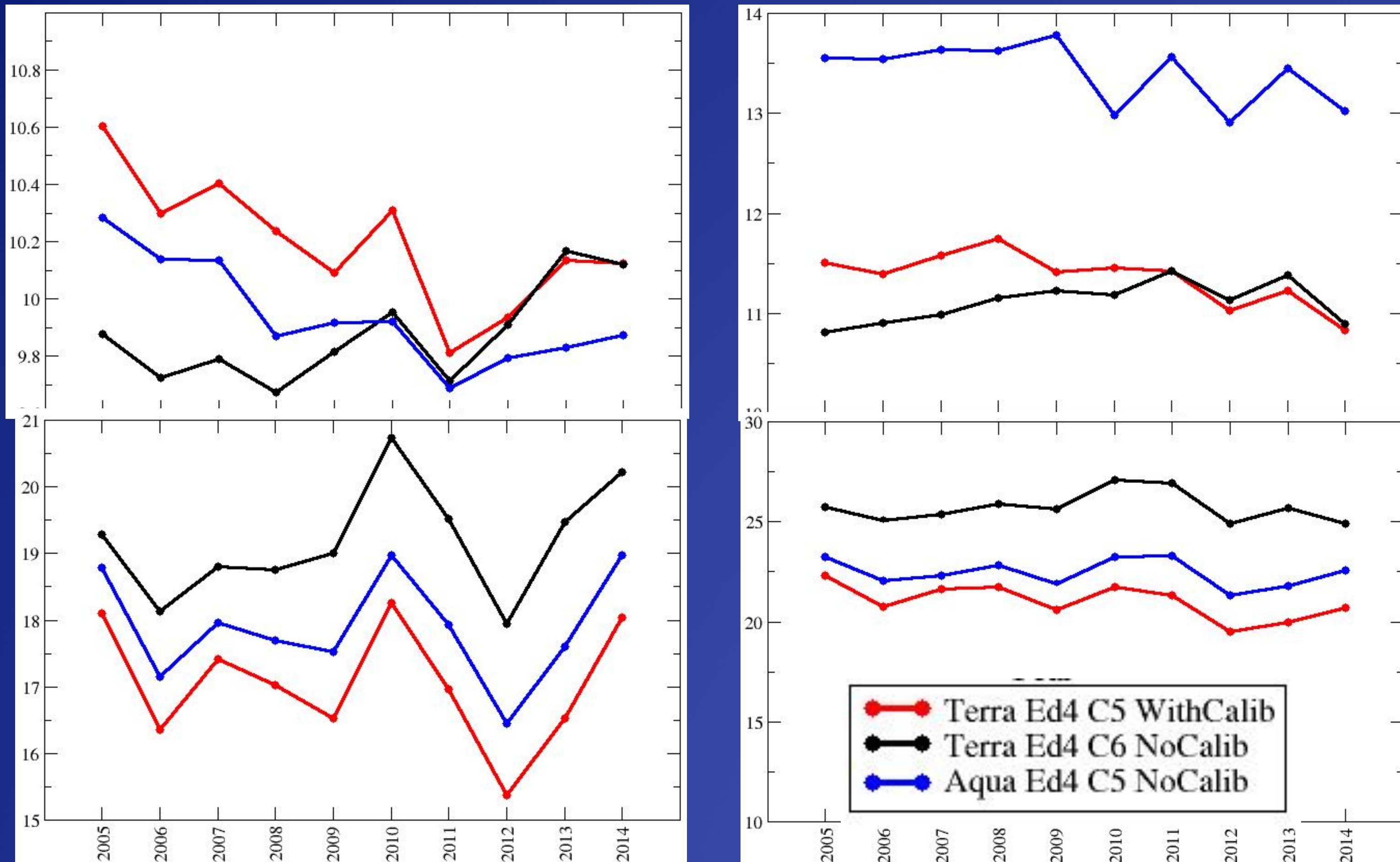
- NP cloud fraction increased ~0.005 over ocean, 0.02 over land
- Better consistency with Aqua over polar regions (other channel calibs)

Day Cloud Optical Depth from MODIS C5 and C6, October 2005-2014

Ocean | Land

Non polar

Polar



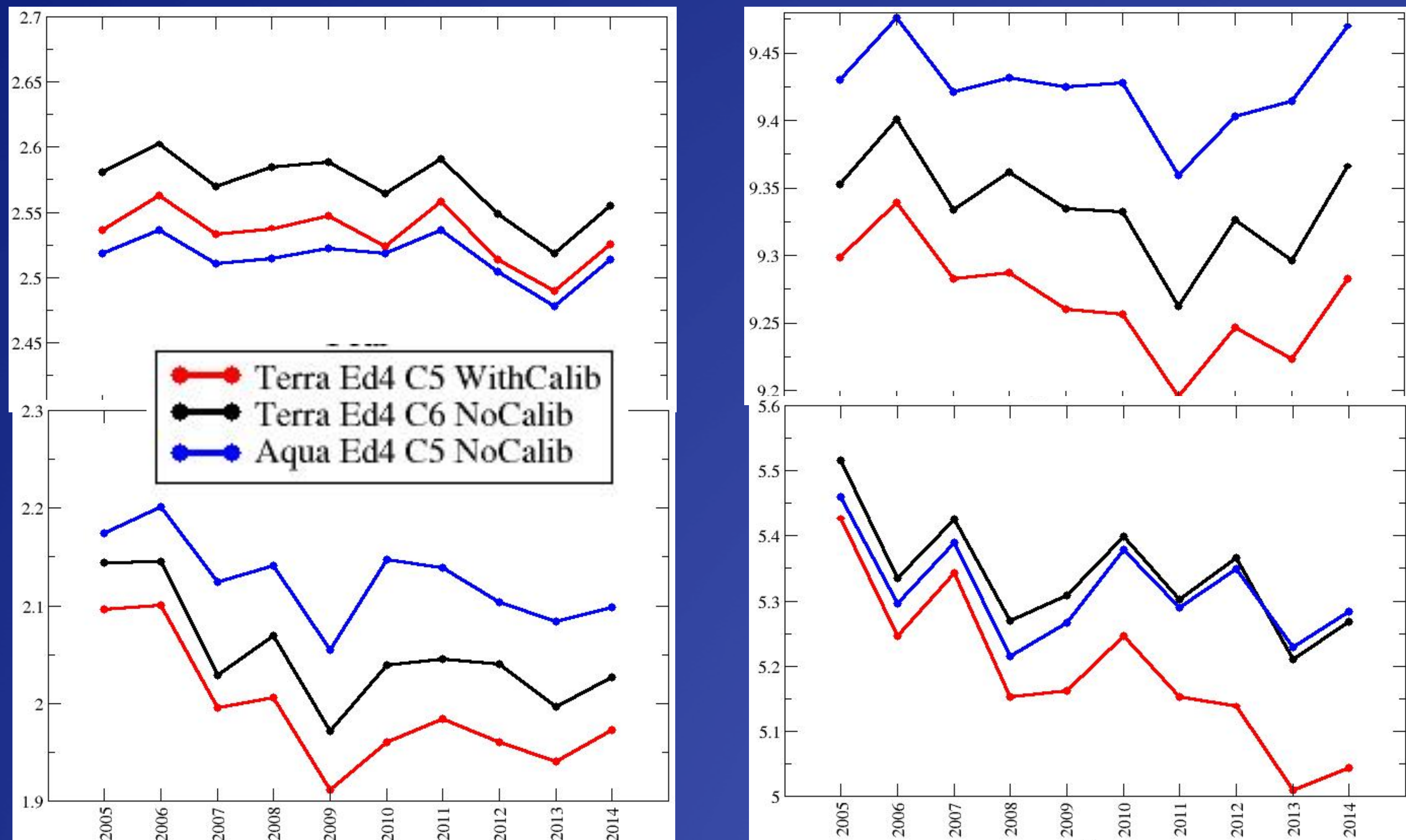
- NP COD decreased ~0.6 over ocean and land, agree in later years
  - *- Aqua calib diminished and took Terra C5 with it*
  - *- C6 not normalized to Aqua, so meets C5 cal in later years*
- Polar COD increased by 2.0 (1.24 μm calib), less consistency w/ Aqua
  - *- need to check Aqua C6*

Day Cloud Eff Height (km) from MODIS C5 and C6, October 2005-2014

Water | Ice

Non polar

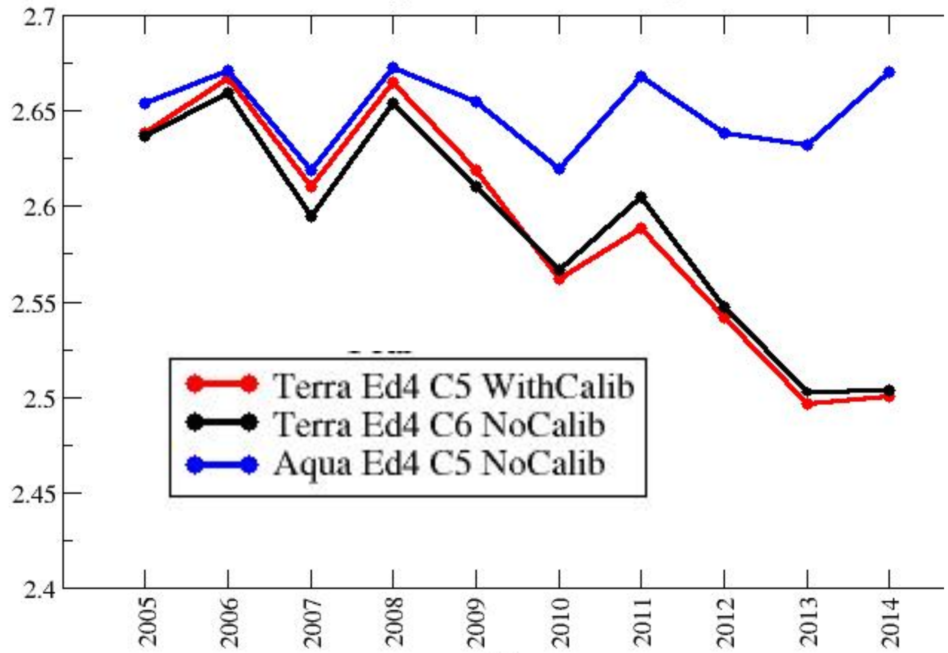
Polar



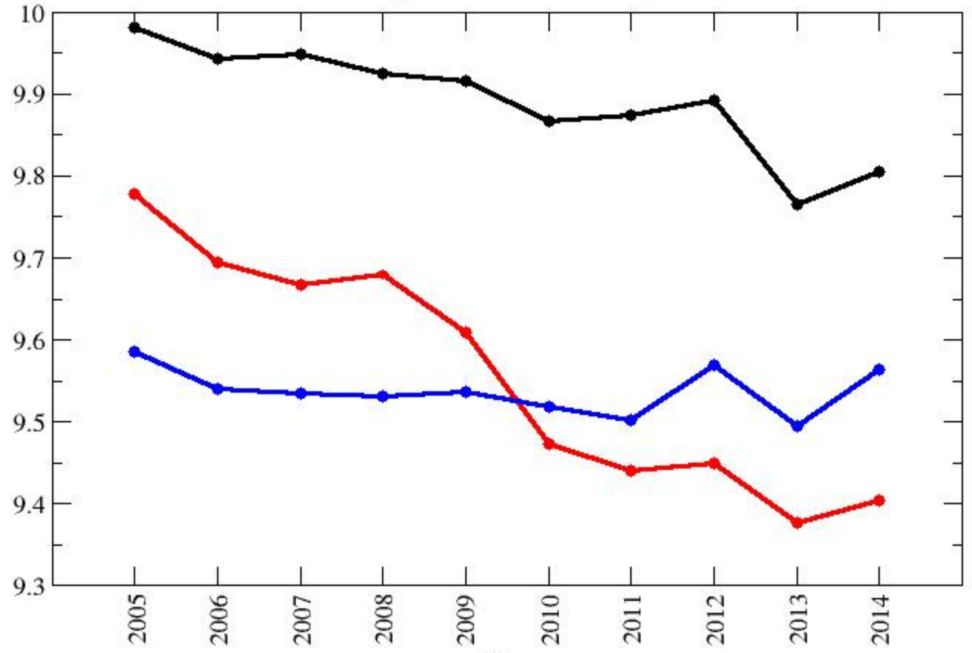
- NP Zeff increased ~50-75 m for ice and water
- Polar Zeff increased by 50-200 m and more consistency w/ Aqua
  - *- need to check Aqua C6*

Night Cloud Eff Height (km) from MODIS C5 and C6, October 2005-2014 Global

Water



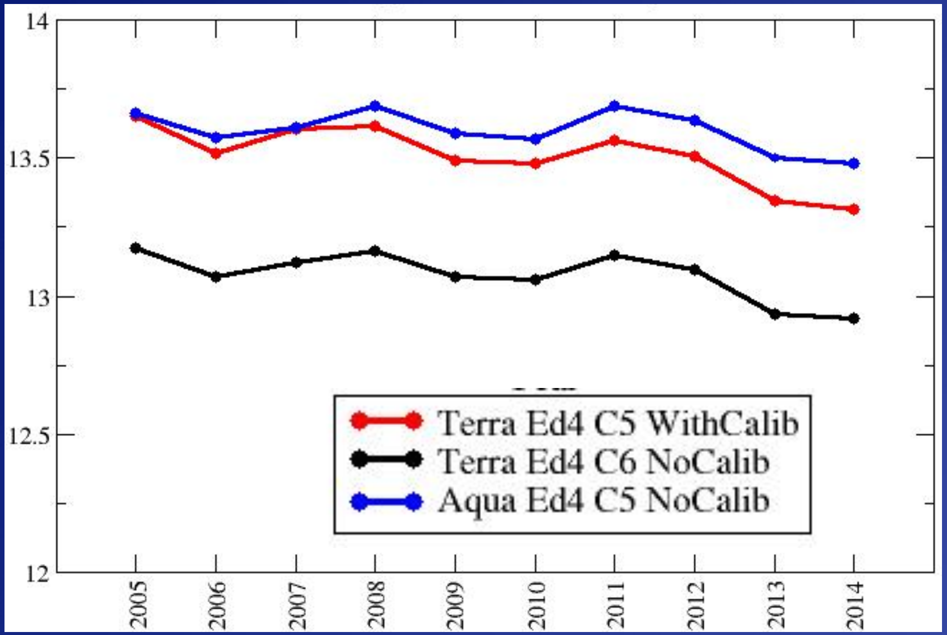
Ice



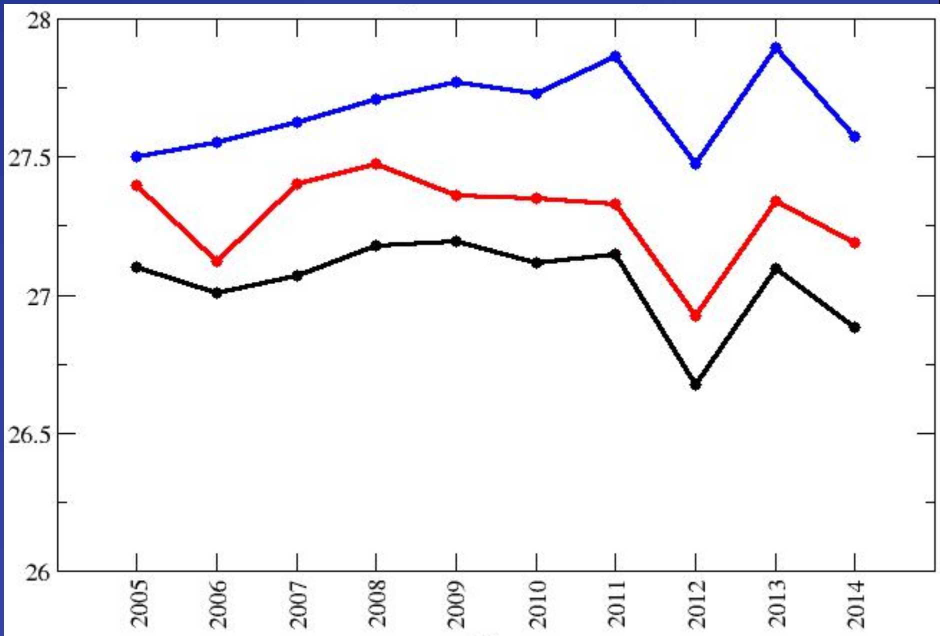
- Negligible change in water cloud heights at night
- Ice cloud Zeff ~200 m higher through 2008, 500 m after 2008
  - *- SIST more sensitive to 3.8-μm calib at lower temperatures*
  - *- Used 2010 correction to 3.8 μm after 2010*
  - *- > 2008 correction may be overdone*

Day Cloud Particle Eff Radius (μm) from MODIS C5 & C6, Oct 2005-2014
Global

Water



Ice



- Reff decreased ~0.5 μm for ice and water

  - Terra C5 normalized to Aqua C5, no adjustment for C6
  - 0.55 K difference => 0.5 μm Reff change

C5-C6 Summary & Future

- Changes caused by C6 calibrations not enormous, but significant
- Most impactful problem is degradation of Aqua calibration
  - induces artificial trends in C5 Aqua and Terra
- Unmaintained nocturnal 3.7 μm corrections introduce trends at night

For Ed5, using C6, we will need to

- Rely on C6 infrared channel calibrations
  - apply daytime normalization for Reff
- Account for Aqua VIS channel degradation after 2008
  - apply constant normalization to Terra to insure Aqua/Terra consistency
- Utilize C6 calibrations for NIR channels
  - adjust clear-sky maps based on C5 calibrations

Ice Particle Models

• New ice model delivered several times from Yang group

- 2 habit roughened: ice columns and aggregates

• Been unable to achieve reduction in cirrus COD with the new model

- published version (Liu et al. ACP, 14) yields 50% reduction

• Interaction with Yang group to acquire the correct model

- been through several iterations
- Liu back in China, model is being recreated with improvements

- no hollow columns

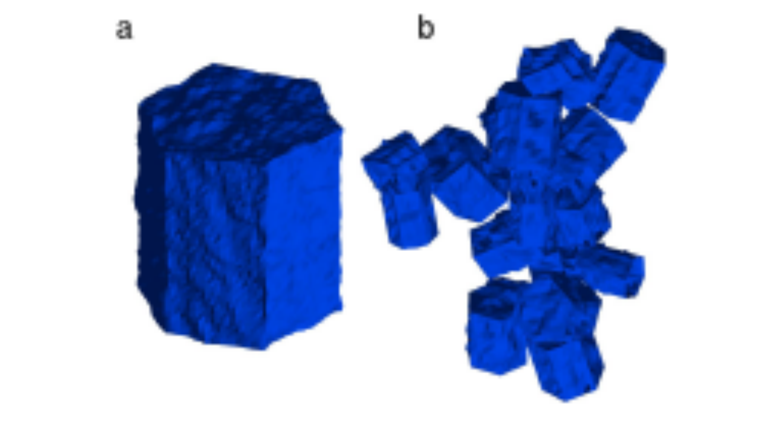
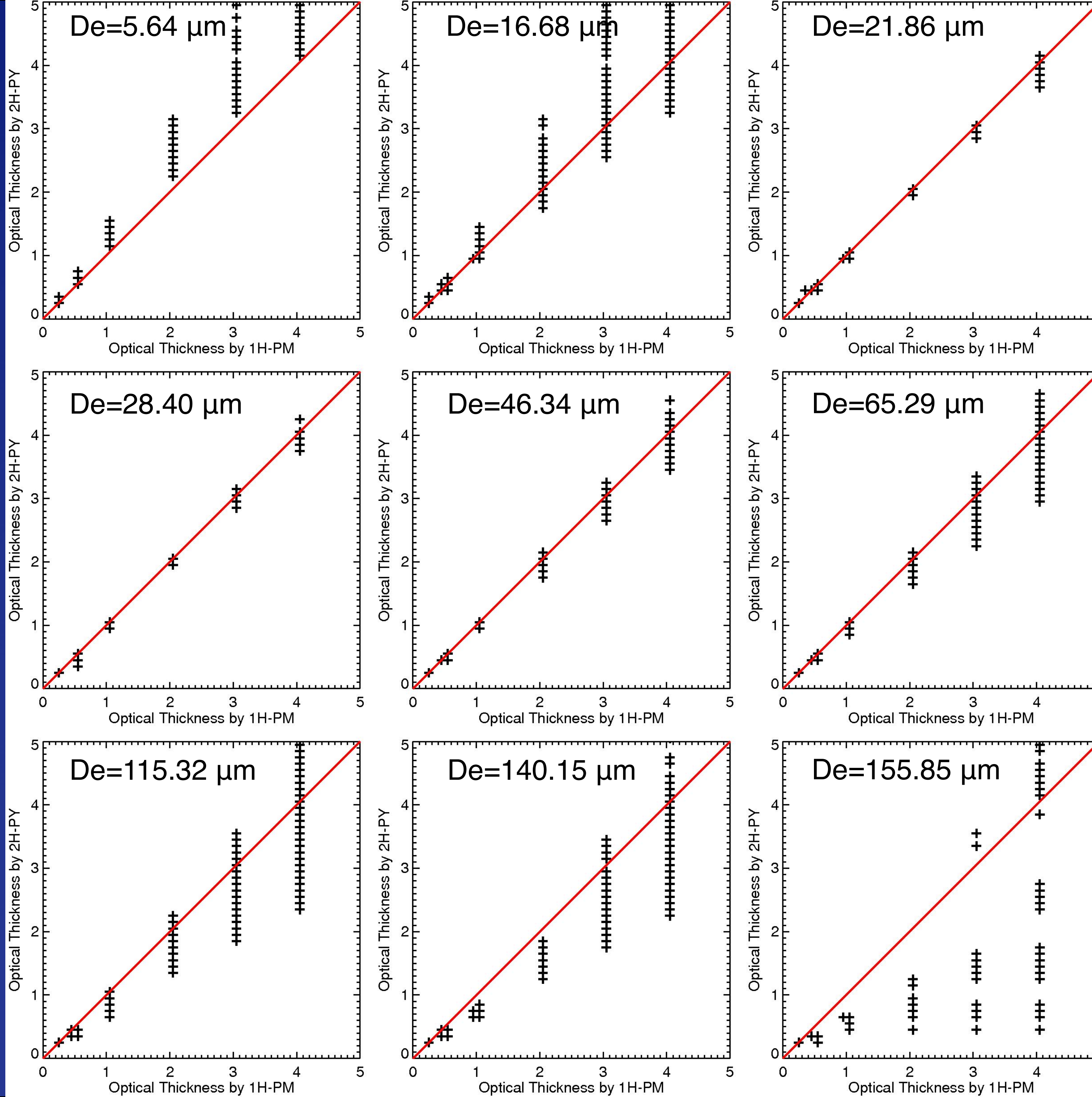


Figure 2. Particle geometries for the two-habit model (THM): (a) single hexagonal column with an aspect ratio of unity, and (b) hexagonal aggregate with 20 solid or hollow columns.

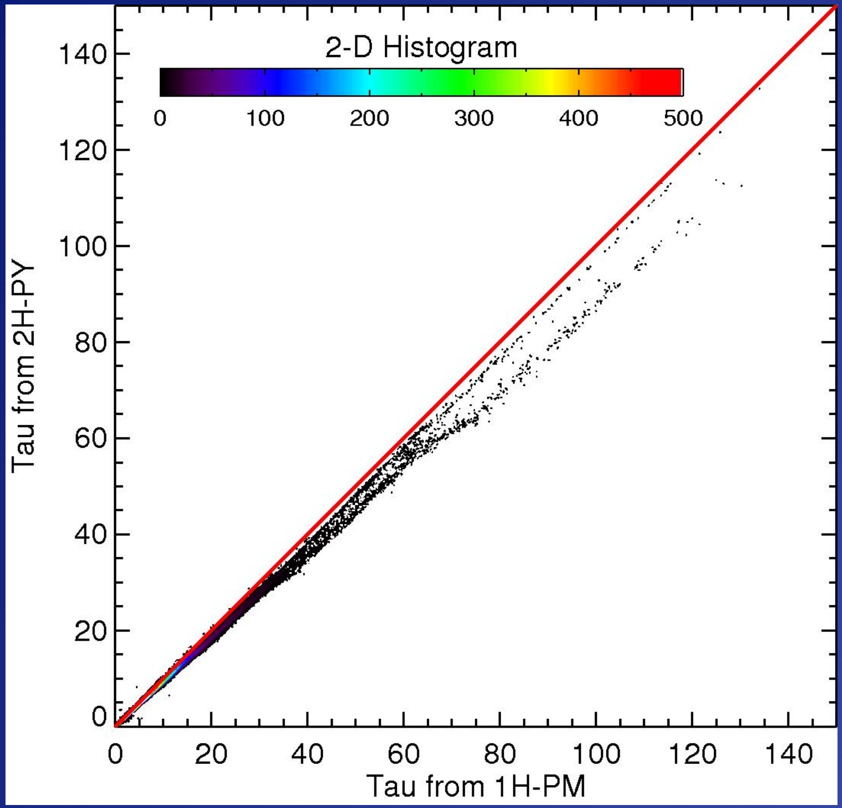
Relationship of 2H and 1H COD for given reflectance, SZA=60°

Only gain of appropriate size for large De

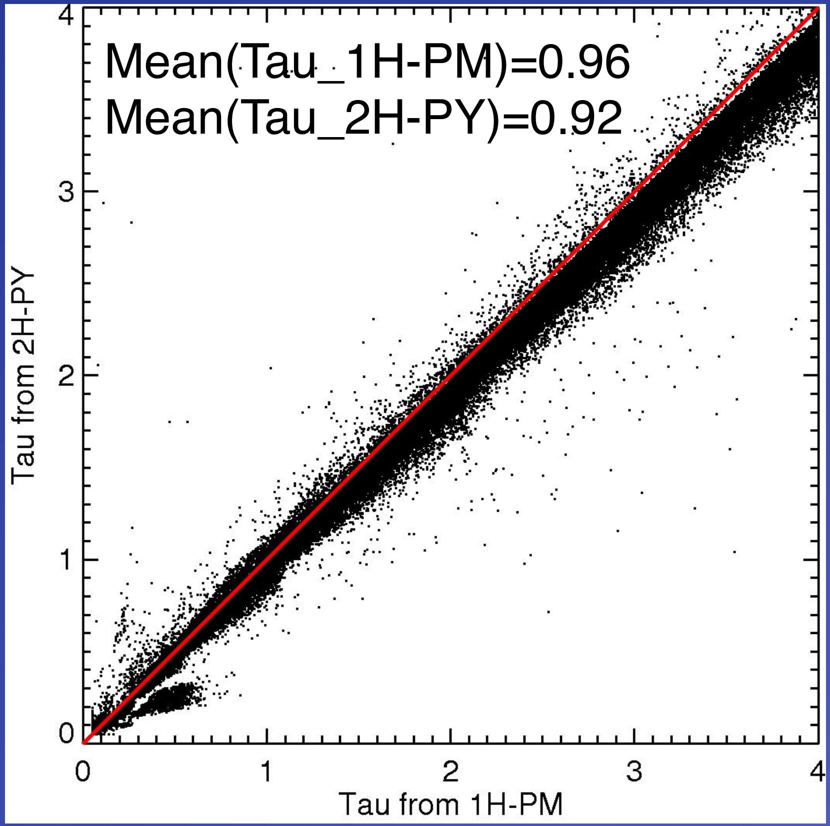


Ice cloud COD retrievals for Aqua MODIS granules using 2H and 1H models

Full Range



tau < 4



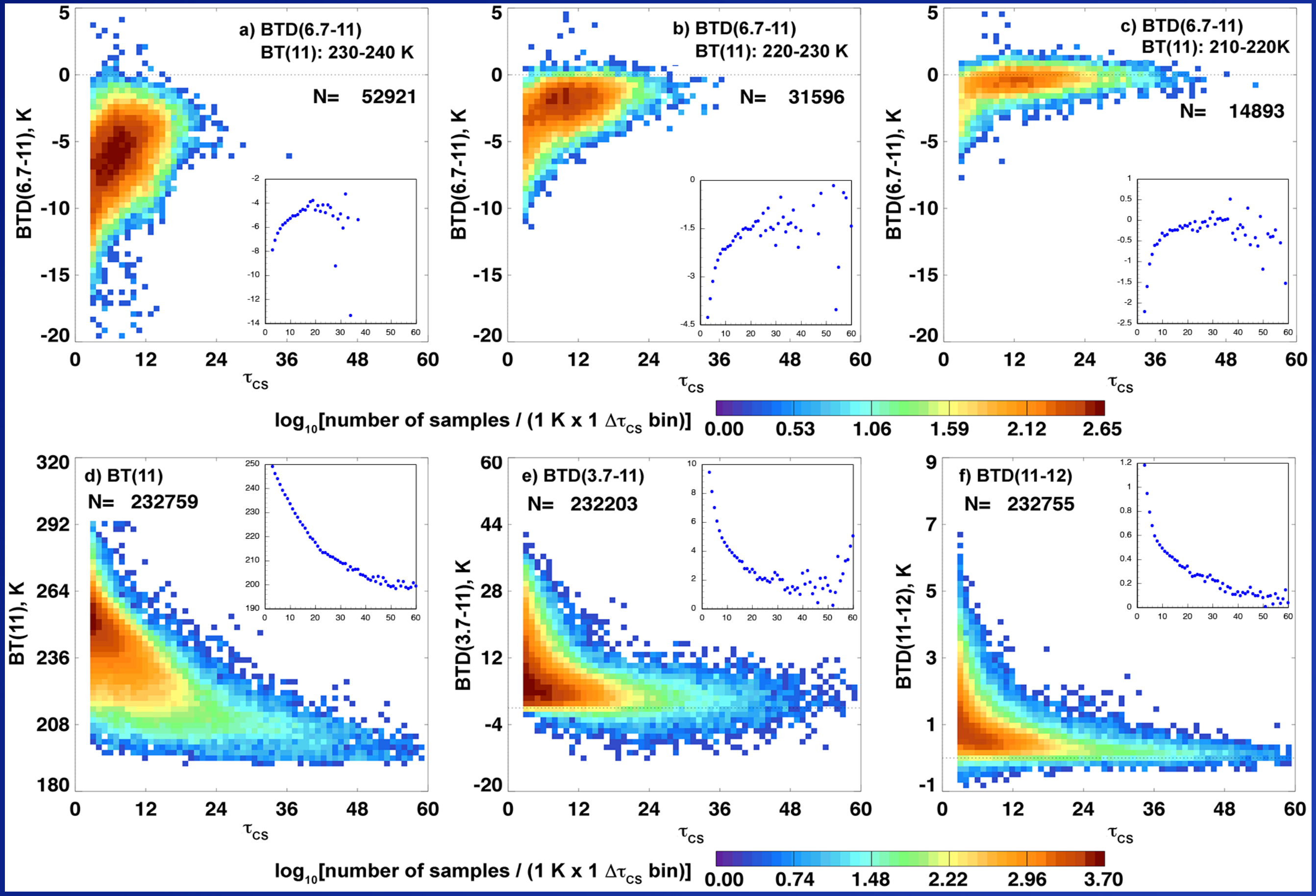
- Less than 10% reduction over the full range
- Only 4% reduction for thin cirrus
  - need new model! Yang group working with G. Hong to generate a new set of models using only solid columns in aggregate

Thick ice cloud COD at night from multispectral Infrared

- Surface longwave radiation affected by cloud base, depends on COD
    - SIST punts for COD > 16, defaults to 32
    - more accurate COD => more accurate cloud base height
- Better estimate of COD => IWP
    - better relationships between atmospheric water and radiation
- Has applications during day to multilayered cloud detection

Examples of Spectral Sensitivity to Optical Depth

- Various IR spectral parameters shown as function of CloudSat Ice Opt Depth

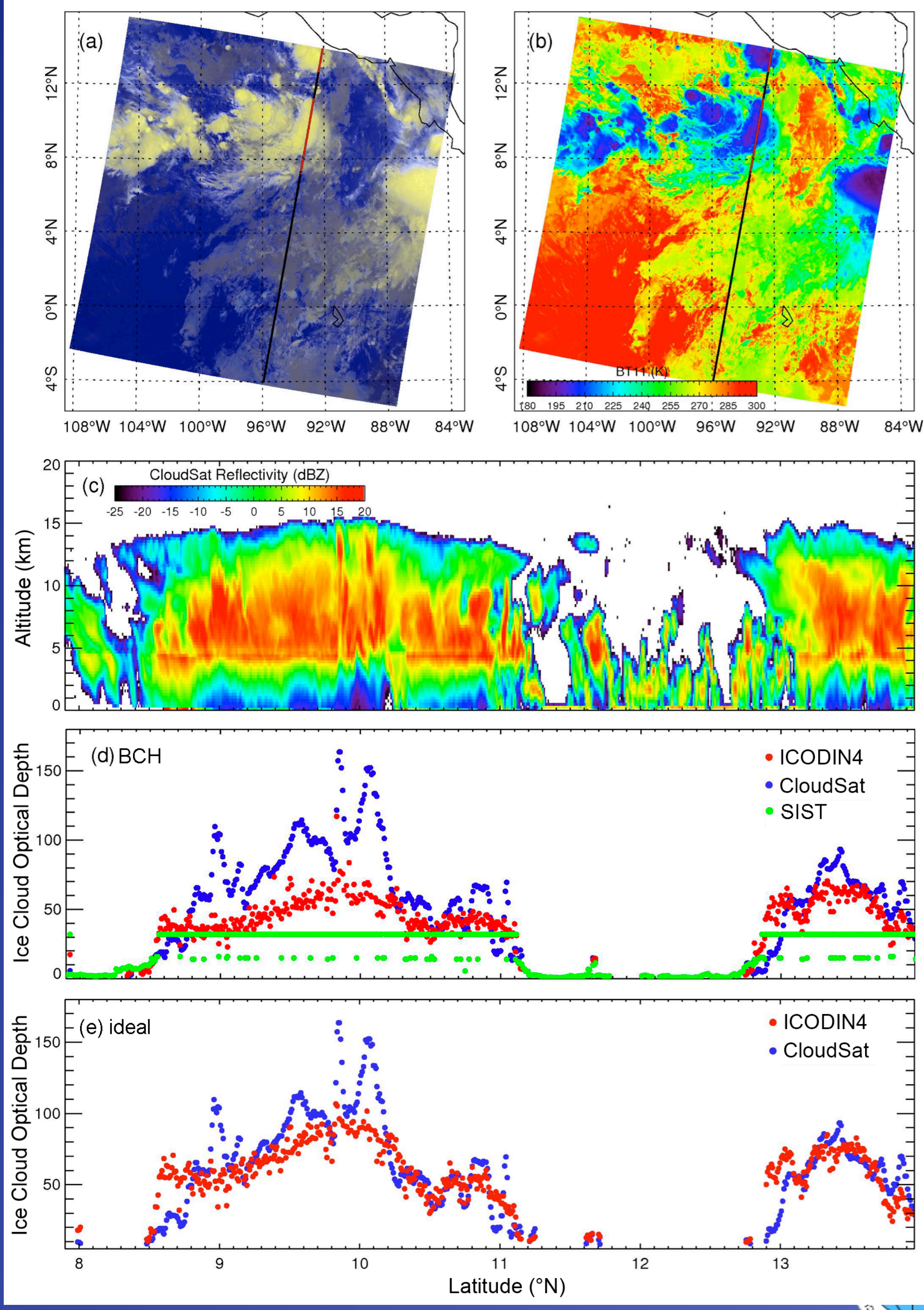


- These different IR spectral parameters are used in an artificial neural network to estimate ice cloud opt depth => can be applied at night

Nocturnal Ice Cloud Optical Depth from Various Methods

- CloudSat provides “truth”
- Standard method, SIST, stops at COD = 16, then defaults to 32
- Neural network trained with passive imager data classified as thick ice clouds (BCH) yields some improvement
- Training using only CloudSat thick ice clouds (ideal) yields very good agreement

- Research on better defining thick ice clouds is ongoing

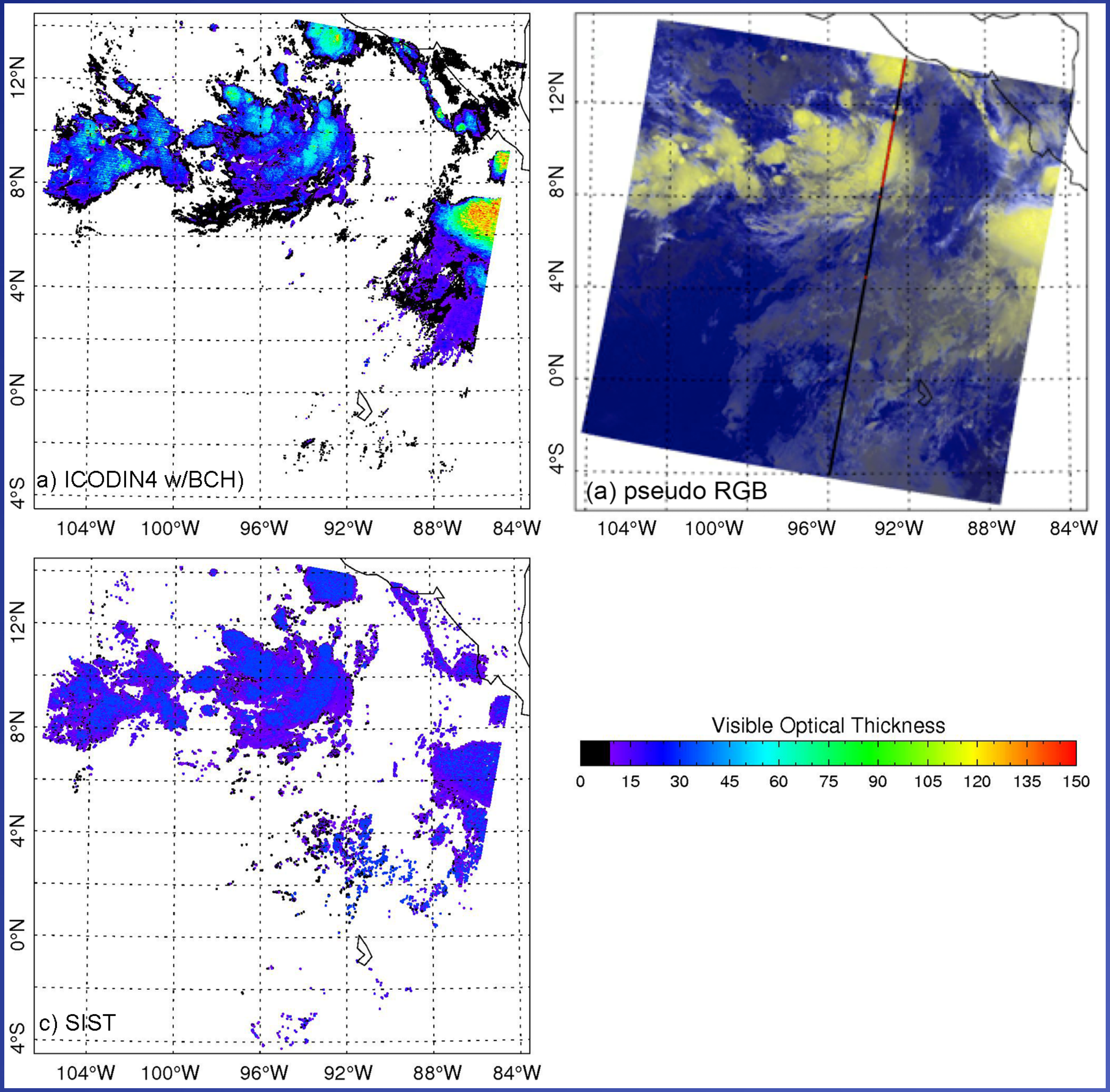


Minnis et al. JGR 2016

Ice Cloud Optical Depth, Aqua MODIS, 0800 UTC, 6 June 2008

- 4-channel ICODIN yields realistic COD distributions

- SIST stops at 32 providing no gradients

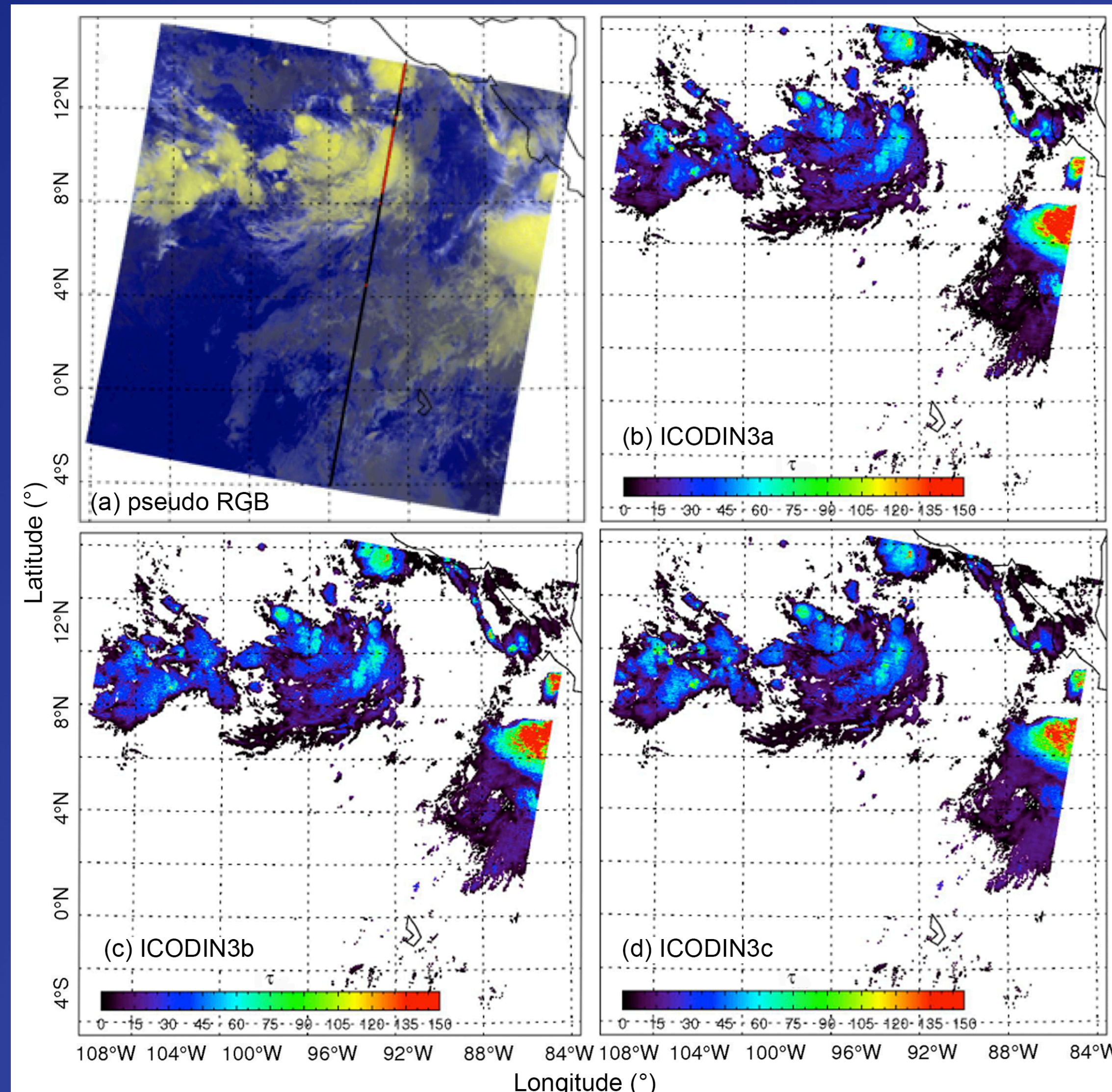


Ice Cloud Optical Depth, Aqua MODIS, 0800 UTC, 6 June 2008

- 3-channel ICODIN versions also yields realistic COD distributions

- Very similar results from all 3 combinations

- ICODIN3a (6.7, 11, 12 μm) can be used in daytime



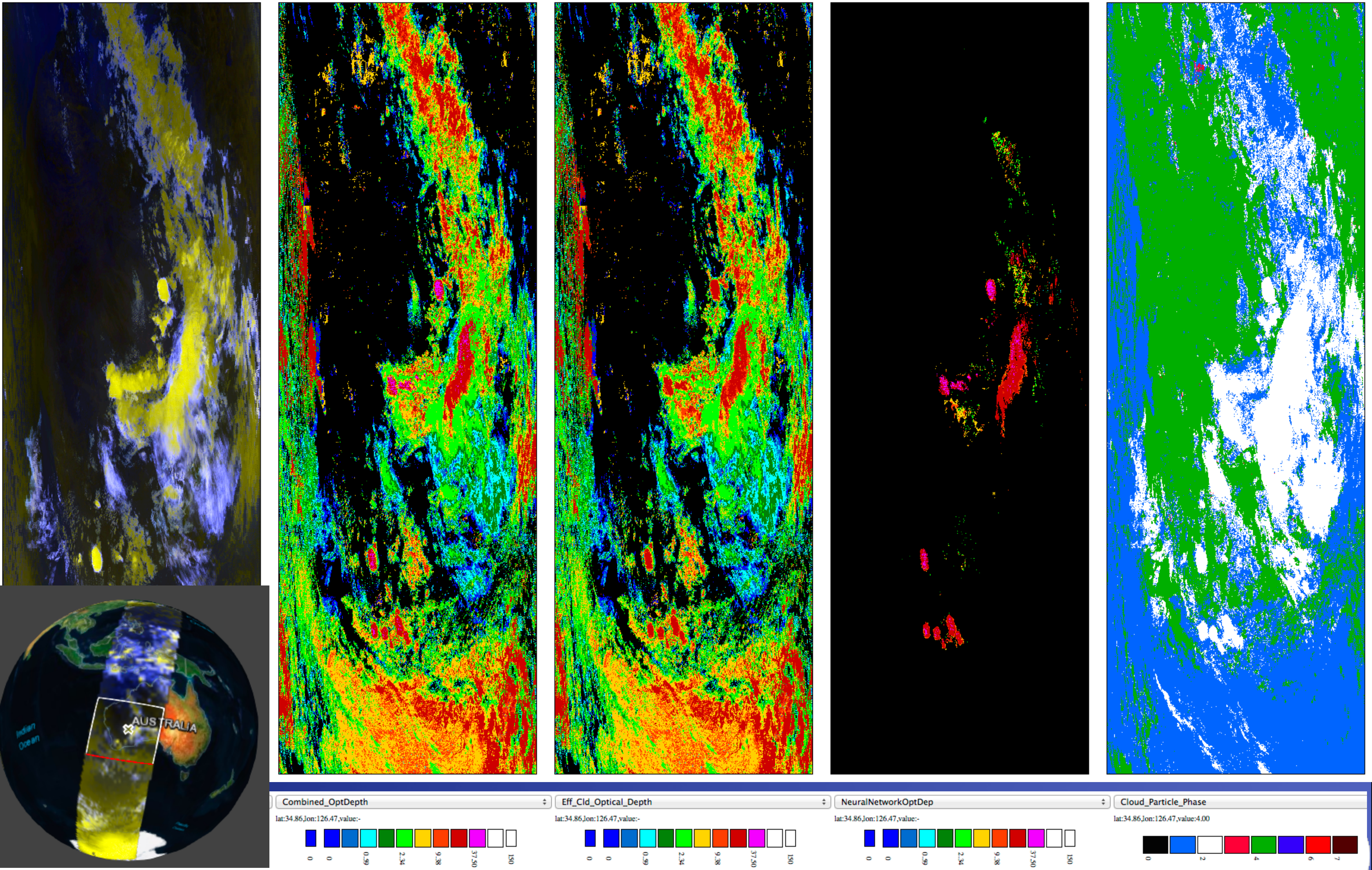
Summary of ICODIN Results: Ice Optical Depth Differences vs. CloudSat

Retrieval Method	Year	Mean	*R*	Bias	Bias (%)	SDD	SDD (%)
BCH opaque only							
ICODIN4 3.7, 6.7, 11, 12 μm	2007	8.85	0.80	-0.07	-0.8	8.73	99
	2008	8.50	0.78	-0.10	-1.2	8.89	105
ICODIN3a 6.7, 11, 12 μm	2007	8.95	0.79	-0.05	-0.6	9.20	103
	2008	8.60	0.75	-0.07	-0.8	9.45	110
ICODIN3b 3.7, 11, 12 μm	2007	8.83	0.79	-0.09	-1.0	8.91	101
	2008	8.51	0.78	-0.10	-1.2	8.94	105
ICODIN3c 3.7, 6.7, 11 μm	2007	8.86	0.80	-0.05	-0.6	8.80	99
	2008	8.51	0.77	-0.10	-1.2	9.13	107
SIST	2007	7.40	0.63	-2.42	-24.6	12.2	124.4
	2008	7.16	0.64	-2.19	-23.4	11.6	124.4
Ideal (BCH & CloudSat opaque)							
Ideal ICODIN4 3.7, 6.7, 11, 12 μm	2007	21.8	0.73	-0.07	-0.3	13.2	61
	2008	21.3	0.71	-0.33	-1.5	13.5	63

- Accuracy of “ideal” case compels development of thick ice ID

Example of ICODIN4 Applied to Aqua MODIS, 1 April 2010

ICODIN4 used when tau(SIST) $\geq$ 8



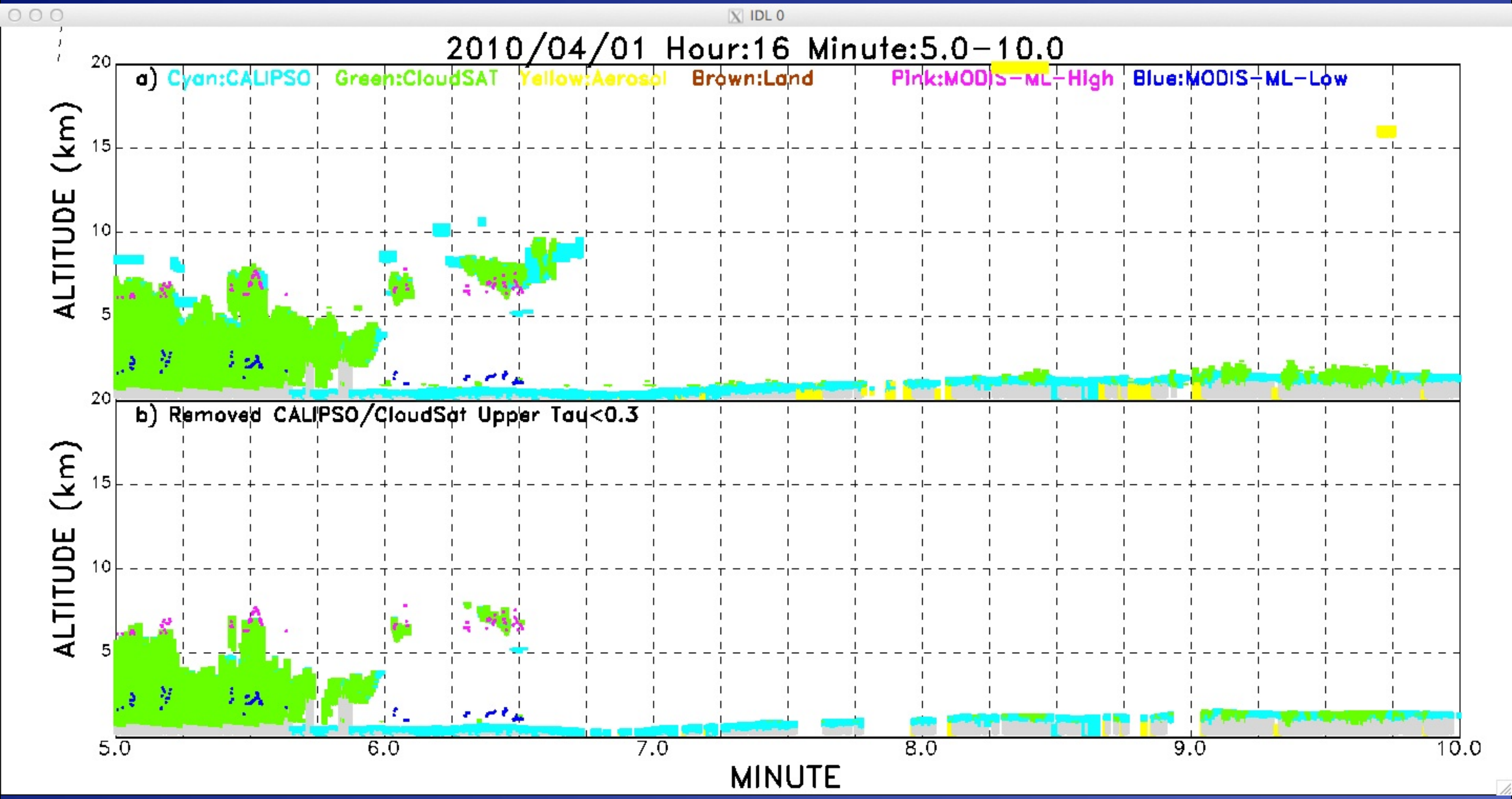
Multilayer Clouds

- Many single layer ice or ice/water clouds being classified as multilayer
  - Viudez-Moro talk on Thursday morning

- Bottom line: need to better identify thick single-layer ice and ice/water cloud systems to end false ML identification

Multilayer Cloud Detection Dilemma: Thick vs. overlap

CloudSat-CALIPSO profile vs. ML layers:



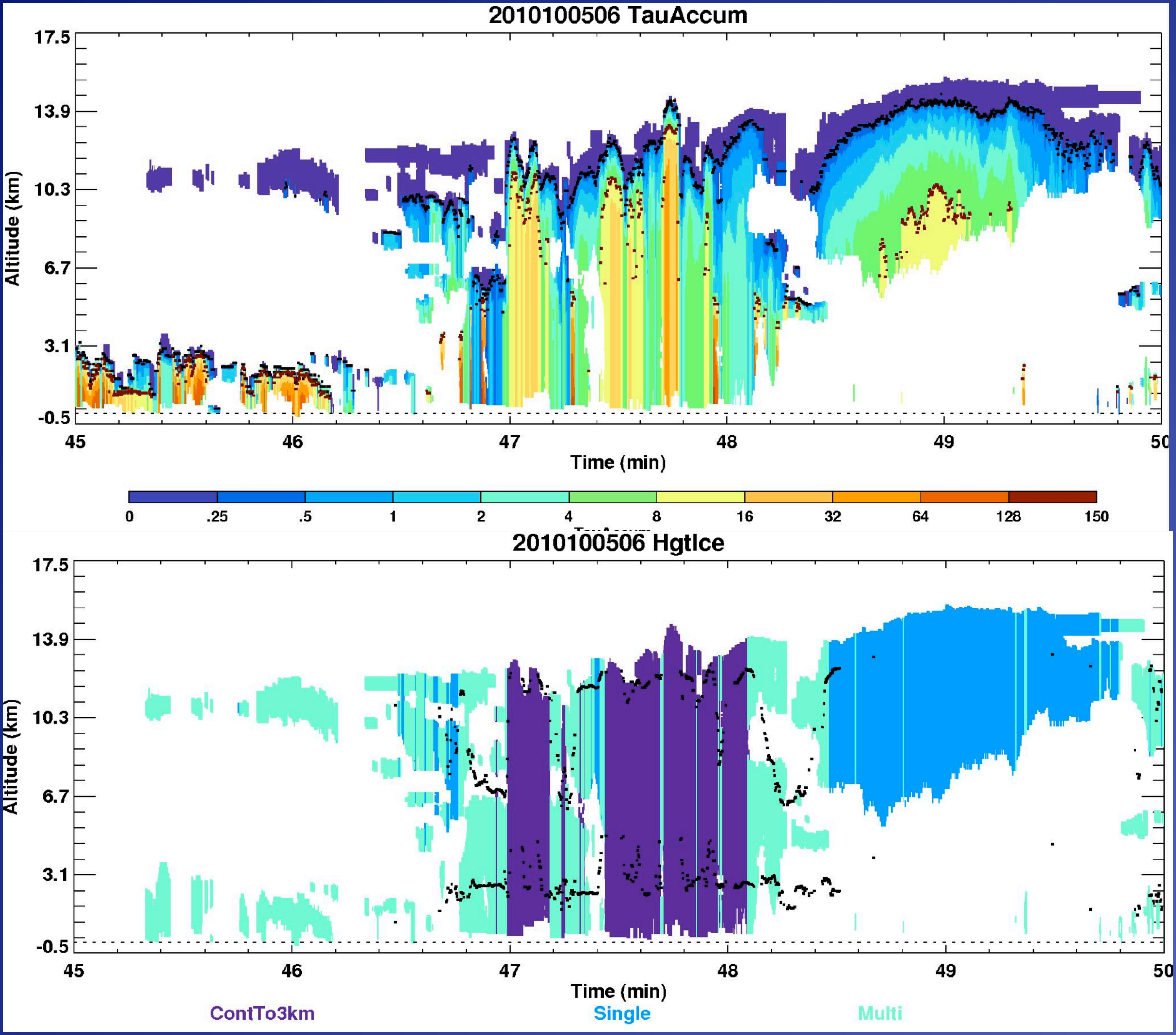
- Typical example, too much thick cloud called ML

Addressing the thick ice cloud systems

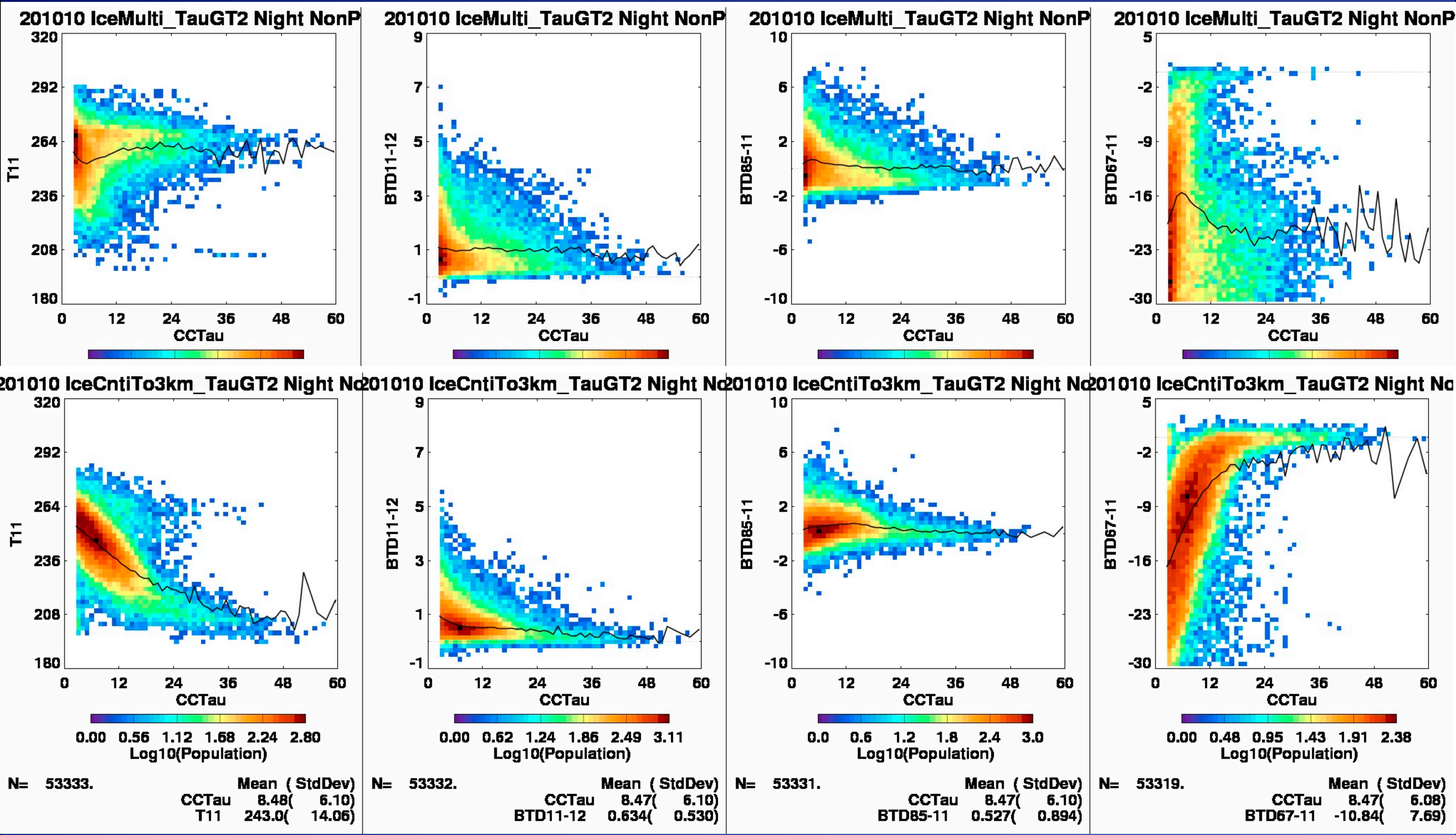
- NN provides information about ice cloud COD

- Develop a different NN system to separately identify thick cloud systems
  - examine signals from various channels
    - *use C3M CC profiles of COD and layering*

Preparing the Data



Histograms of temperature and BTDs for thick ice and multilayer ice/water



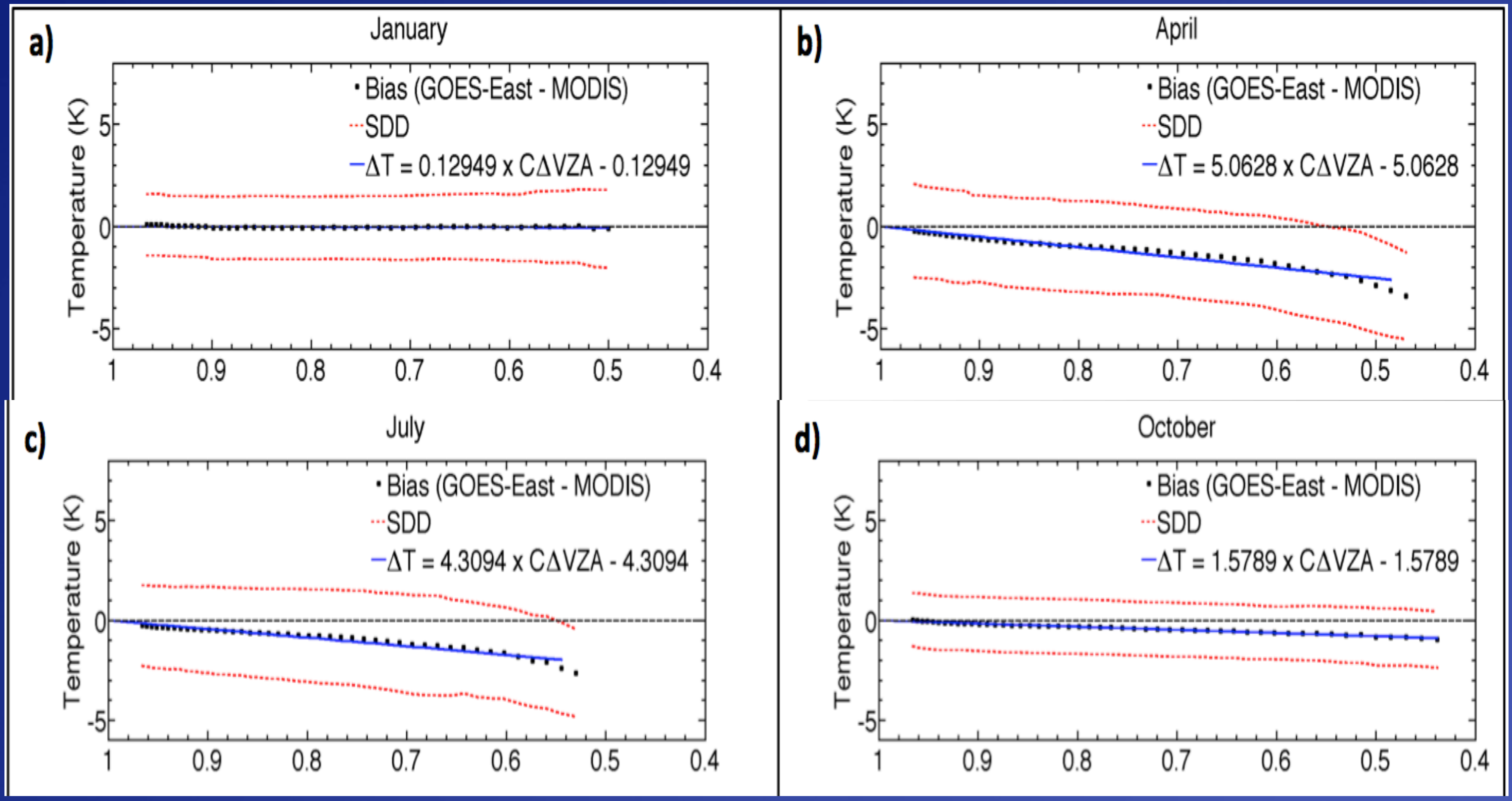
- Best differentiation appears in T11, BTD67-11, 11-12, 85-11
  - can add single-layer VIS COD in daytime

Improving Single Channel Surface Skin Temperature Retrieval

- Account for VZA dependence over land
  - develop empirical models using matched MODIS and GOES
- Improve pixel-level retrievals
  - apply a ratio technique within each analysis tile
- Determine sensitivity to input profiles
  - tested GFS and MERRA
    - *not much difference over land sites*
    - *MERRA a little better over ocean (SST)*

Scarino et al. AMTD 2016

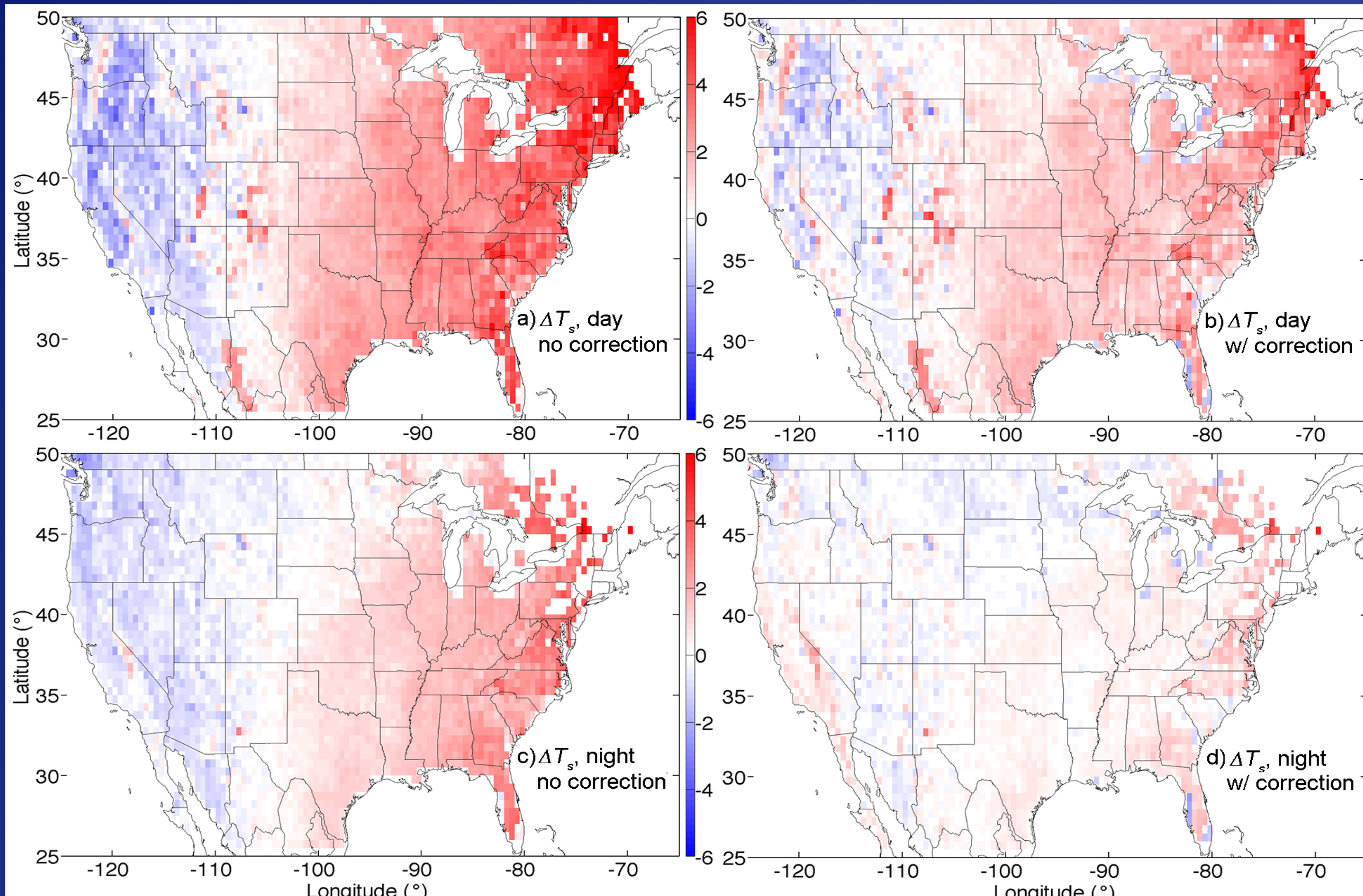
Empirical VZA-correction Model



- Dependence least in winter, greatest in summer

Viewing Zenith Angle (VZA) Impact on Retrieved Skin Temperature

Example: GOES-East – GOES-West regional LST differences, July 2013



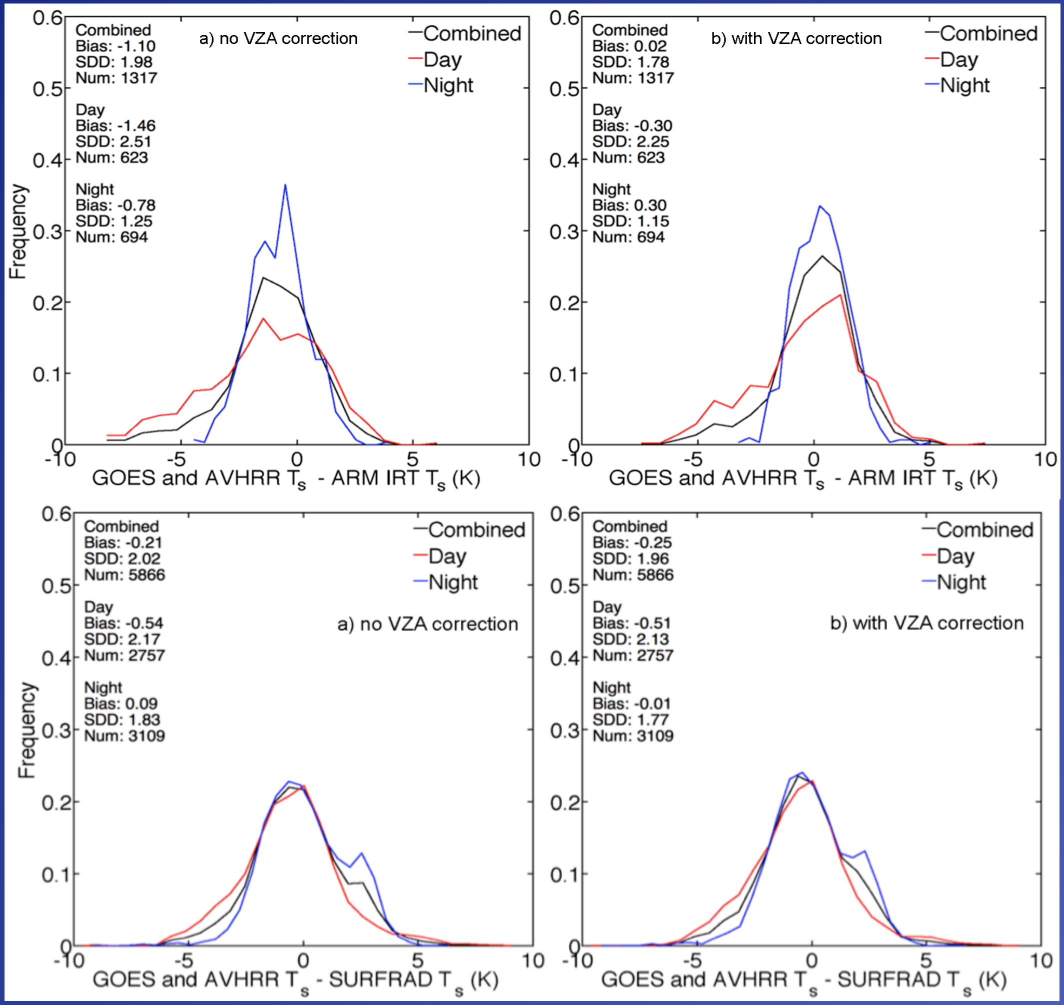
- Viewing zenith angle correction GOES E-W difference

  - azimuthal effects still persistent during the day

Validation: US Surface Sites

- Dramatic reduction in bias fro nadir viewing IRT comparison at ARM site

- Smaller gains for BSRN pyrometer measurements (corrections to VZA ~53°



ARM SGP

BSRN

- Results as accurate as any skin temperature retrieval method

The End